FEEDS AND FODDERS

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CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE
NOV 1952
LIBRARY
MYSORE.

PUBLISHED BY
THE BANGALORE PRINTING AND PUBLISHING CO., LTD.
MYSORE ROAD, BANGALORE CITY

First Edition . . . . . .
Second Revised and Enlarged Edition . . . . . .

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Feeds and fodder

PRINTED AT THE BANGALORE PRESS, BANGALORE CITY

FOREWORD

THE contents of this book appeared originally as a series of popular articles contributed by the author to the *Monthly Bulletin of the Bangalore Dairy Cattle Society*. They are now published in a collected form, in the hope that they will be of use to a wider circle of readers. The book is expected to serve as a useful companion volume to the author's "Milk and Milk Products", published recently.

January 1945 *The Author*

PREFACE TO THE SECOND EDITION

THE first edition of this little book has long been out of print but there has been a steady demand all the time, which could not be met. As the book is evidently meeting a real need it has been thought desirable to publish a second edition. The publication of this new edition has been availed of to widen somewhat the scope of the book without altering its original shape as a series of popular articles published in a popular Dairy Journal *viz.*, the *Monthly Bulletin of the Bangalore Dairy Cattle Society*, now being issued under the title of *Indian Dairyman*. Considerable new matter has accordingly been added, which it is hoped will not only make it fairly up to date but also enhance its usefulness. For instance, the subject of pastures has been dealt with in more detail, a larger number of well-tested rations which include many kinds of feeding stuffs according to regional peculiarities has been described, and finally an account has been given of the measures adopted in Mysore by way of relief during a period of acute shortage of fodder amounting to a famine. Fodder famines are only too common in many parts of India and it is hoped that this account will be found to afford some useful guidance to those who may be entrusted with the task of combating a similar situation should one unfortunately arise.

Consequent on the very large and rapidly expanding demand for milk all over the country, dairying is developing by leaps and bounds and great efforts are being made in many directions to help the industry forward. An adequate supply of cattle feeds will however remain the foundation of the industry, and in a sense even more than the breed of the animals kept ;

but unfortunately due to various causes, the supply of feeds whether green, dry or concentrated, remains very unsatisfactory. It is hoped that this book will both stimulate interest in and promote a knowledge of the subject and contribute to an improvement in the situation, to the extent that a book can be expected to do in a matter of this kind.

My thanks are due to Dr. K. C. Sen, the present Director of the Indian Dairy Research Institute, for his kindness in allowing me to publish the photographs of the fodder grasses which appear in this edition and to Sri. G. Srinivasa Rao, Superintendent, the Bangalore Press, for the neat get-up of the book.

THE AUTHOR

INTRODUCTION

In the following series of articles we propose to deal in a popular manner with the characteristics of the various diffreent cattle feeds and fodders that are available in our country and are in common use, together with their products and methods which though in vogue only in foreign countries, can still find useful application in our country as well. We shall also try to make the list as complete as possible, and include in it the natural grasses, the various green crops grown specially for fodder, the dry fodders like hay, straws of different kinds, special feeds like ensilage, the various concentrated feeds like the grains, pulses and their bye-products, and the oilseeds and oilcakes. Considerable scientific work has already been done in our country on these fodders and an attempt will be made to include such results as may have a direct practical bearing on the feeding of dairy cattle.

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FEEDS AND FODDERS

I

PASTURES AND GREEN GRASS

GREEN grass forms the most natural food of cattle and under the conditions of nature cattle thrive normally on such food alone. They grow, fatten, produce their young, afford enough milk for their sustenance and growth, and a moderate surplus for human consumption. Under the pastoral conditions of human society the requirements in respect of milk and milk products are more than adequately met from purely pasture-fed cows. The milking of the cows in the morning, the song of the dairy maids, the driving of the cows to the pastures after they are milked, allowing them to roam and feed at will over pastures blessed with an abundance of flowing water, alongside streams and waterfalls, and shepherding them to cool spots under the shady trees and groves where they chew the peaceful cud and rest during the hot hours of the day, while the shepherd lulls them with the music of his pipe ; the browsing of the cows once again in the luscious grass, the drinking of the clear waters of sparkling waterfalls and the gathering together for the march homeward when the sun begins to set ; the arrival in the village which now resounds with the bleating of the calves and the answering cries and caresses of the mothers, which is followed by the noise of the suckling calves and the filling of the milk pails—such is a poet's description of cow-keeping in such surroundings and abundant pastures. With the changed conditions of life and the large extension of cultivation however such pastures are dwindling to vanishing point and can be seen if at all only in rough hilly or forest tracts unfit for use as plough land, although even such favourable tracts are clothed with plantations where cattle are most unwelcome intruders. It is to grass, cultivated, cut and brought home or to other forms of bulky fodder supplemented largely

by concentrated feeds that the farmer has to look nowadays for the satisfactory feeding of his cows. Pastures are nevertheless essential where cattle can roam at will and feed on what nature has meant for them under natural conditions both for the sake of the feed and of the outdoor free air and exercise. Natural pastures often possess advantages which are by no means to be neglected, as against artificial pastures sown with special grasses and looked after carefully ; their mixed herbage which afford a varied assortment and to which cattle are naturally attracted is their chief merit. This point is further dealt with under artificial pastures or leys. Both cows and buffaloes can be seen kept in crowded modern cities confined practically within their stalls throughout the period of their life in the city ; open spaces are *non est* in many cities and where they do exist municipal laws forbid the use of such places and even of the public highways for the walking about of cows—a restriction which deserves to be adopted by all towns, as in these days of motor and other fast moving traffic, cattle even if led and in charge of an attender are a danger, while if they are free roaming they form a serious obstruction of traffic, whether vehicular or pedestrian. We read even of extreme cases where city cows had been kept in the upper floors of milkmen's dwelling houses, where, shut out from the light of day, they spent their whole life or at any rate the useful part of it, whether they were in milk or were dry, where they calved, gave their milk, were got into calf again and went through another cycle. It is thus possible to dispense with pastures altogether and still carry on cow-keeping but it is hard to believe that milk produced from cows kept under such unnatural conditions can be as conducive to human health as milk produced under better conditions. Even out in the countryside cattle keeping becomes very difficult if the nature of the cultivation is such that little or no open grazing ground is available to animals, for them to roam about at least even though there may be only very little grazing. Such conditions prevail in the tracts of extensive rice cultivation, such as in the deltas or in channel areas of Mysore, where every inch of land is under rice

cultivation and cattle have only the village surroundings in which to move about.

Pastures may be of two kinds, *viz.*, those which are natural and those which are artificial, *i.e.*, which are laid out specially and looked after, or which though formed naturally are reserved as pastures and carefully attended to. The artificial pastures are seldom found except in countries where animal husbandry and dairying play a large part and the population depends upon imported grain for their cereal food. It is thus a great feature of British agriculture and the pastures of England are famous and the people are proud of them ; nothing but the stress of war and the paramount need for producing more food grains could reconcile the British farmer to breaking up his grass land. These pastures are either temporary, lasting for a few years and then broken up and given over to arable farming or they are permanent, remaining as pastures save when dire need demands their conversion to plough land. Artificial pastures of a sort can be seen in Mysore in the horse-breeding farm in Kunigal and the grass farm in Hessarghatta near Bangalore. These are partly natural pastures preserved and worked as such and partly arable land sown to grass and converted into pastures. Some are walled in paddocks and some open pastures but grazing is very much limited and in any case strictly controlled, the main aim being to cut the grass for making into hay. With this insignificant exception the pastures in Mysore are all only natural pastures.

The pasture lands in Mysore comprise firstly the so-called grazing lands or *gomals* attached to villages, secondly the forests, hillsides and rough wastelands which are far away from agricultural tracts and are also unfit by virtue of their situation for cultivation. Both these types of grazing or pasture land furnish grazing only in the rainy season generally from the month of September onwards when the grass has had time to grow. After the rainy season is fully over and the ground begins to dry up these pastures afford little or no grazing and are pastures only in name. A third class of pastures are what are called hot-weather pastures. These exist in the

extensive areas which form the catchment of tanks, in shallow valleys, on the sides of creeks and rivers which overflow their banks in the rainy season; in all these situations as the water recedes a great extent of land which was under water becomes exposed and is soon filled with grass growth, which lasts through a good portion of the hot weather. The soil in most of these situations is clayey and often of the black cotton soil type which has a high water-holding capacity and is also very retentive of moisture which is generally sufficient to sustain grass growth for a much longer period than on other soils. The village grazing grounds and indeed most of the pastures in the *maidan* districts furnish so little grazing that their value as pasture is negligible; this is so because firstly the rainfall is low and often precarious and secondly because the grass is eaten up as it appears by the hordes of hungry cattle and therefore makes little or no growth. In the tracts of heavy rainfall whether on the hills or on the open downs grass is plentiful and for the time being at least they form good pastures and as a matter of fact cattle from the *maidan* country are marched to these distant tracts, where they remain as long as the grass is flush, generally from September to January, and are then marched back at the advent of the hot whether.

Drought Resistance

It will thus be seen that the value of the pasture is in direct proportion to the rainfall and the soil moisture, if we exclude the custom of unrestricted grazing. There is no grass which can stand and keep growing on purely rainfed land during the hot weather, though there are some which can survive the hot weather and grow up again with the beginning of the rains. Now and again new grasses are introduced for trial which are reputed to be drought-resisting, but we have yet to see any which really can sustain this claim. A long time back the grass *Paspalum dilatatum* was introduced; later on and somewhat recently a grass of the name "Kikiyu" (*Pennisetum clandestinum*) was brought in; neither however could stand the drought. Some of the local grasses especially the coarser ones with a very large root development

which grow in tussocks, the spear grass, the creeping *hariali* (or *doob*) and the newly introduced Napier grass (the dwarf variety) can withstand considerable drought, and, if the rainless period is not very prolonged, may be seen to continue in a green condition. If the soil is moreover of the black cotton type, the conditions become a little more favourable. The scope for drought resistance in grasses would appear to lie in such grasses as would possess great vitality, which would persist growing and remain in a green condition for the maximum length of time after the cessation of the rains and which possess such extensive and vigorous root spread that they will start growing with the very first rains. The above mentioned grasses are of that type and it will be desirable to look for more of the same kind and put them under trial. The case is somewhat different with the deep-rooted leguminous pasture plants which, especially on the black cotton soils, can be seen growing even in the dry months. Many years ago some varieties of so-called "dry-land lucerne" were got out and tried in Hebbal under cultivation on dry-land ; though many clumps dried up and some were destroyed by white-ants there was a fair proportion of the clumps which kept green and survived ; if the plants had been tried on the black cotton soil they would certainly have proved better. But when all is said and done, it is true that these village grazing grounds and rainy season pastures are valueless in the dry season. In practice however, in times of severe and prolonged drought, which unfortunately are not infrequent in this country, reliance will have to be placed only on what may be called emergency fodders, which comprise trees and shrubs, or spiny cactus vegetation which will have to be properly treated by singing the spines before feeding. Further reference to this subject is made under 'Emergency Fodders'.

Factors Influencing the Value of Pastures

Whatever the pasture, whether merely a rainy season pasture or a hot whether pasture, its value will depend upon the quantity of grazing it can afford and also on the quality of the grass. Both these are largely influenced

(1) by the rainfall, (2) by the nature of the grass growing, (3) by the soil (4) by the time that the grass has been allowed to grow, before cattle are let in to graze. We shall now deal with each of these factors one by one.

(*a*) *Rainfall.*—The amount and distribution of the rainfall and the resulting soil moisture are indeed the most important factors which decide the value of pastures. It is extraordinary how quickly—almost overnight one may say,—the young grass shows up after the first good rains of the season ; the growth is kept up and the pastures become covered with a fine crop of grass if the rains should continue at frequent intervals.

In countries where there are rains at such intervals in every month of the year the pastures afford grass in abundance and keep green all the year round, except where the winters are so cold that all growth comes to a stand still. In Mysore and elsewhere in South India the best pastures are in the tracts of heavy rainfall and the abundance of the grass available will almost be proportional to the rainfall. A good rainfall map of the tracts will serve equally well to indicate the distribution and quality of the pasture in these areas. Both quantity and quality are influenced by the rainfall and within limits the higher the rainfall the more heavy is the growth and the better it is generally in quality also. It is however in increasing the *quantity* that rainfall plays the largest part. Very heavy and torrential rainfall such as occurs in the western part of Mysore and in the districts on the west coast during the South-West Monsoon, appears, however, to reduce the quality of the grass ; it is a very general belief that the *malnad* pastures are very innutrious. As a matter of fact the chemical analysis of grass from some at least among pastures in these tracts shows that it is very low in protein and in mineral content. Mixed herbage from pastures in the central and eastern districts of South India for instance have been found to contain an ash or mineral content almost double that contained in the mixed herbage from the districts of very heavy rainfall like those on the west coast and the adjoining ghauts, and this difference is generally reflected in the content

of lime also, although in a much less degree. No general conclusion to this effect can be drawn, but taken together with the largely-held belief that the grass in these tracts is of low feeding value, it may be accepted that the very heavy rainfall affects the quality prejudicially. The effect is also possibly indirect, being due partially at least to the kinds of grasses favoured by the heavy rainfall and the poverty of the soil due to the continuous erosion.

The quality of the grass from one and the same pasture will often differ according to the season. It has been found for instance that pastures in the summer months, are not as rich in proteins and mineral constituents as they are in the winter months, although the yield of grass in the former is many times more than that in the latter season.

(*b*) *Kind of Grass.*—The next important factor affecting the value of pastures is the kind of grass or other vegetation of which it is made up. Pasture grasses differ very materially from each other in the quantity or weight of grass they yield in a particular period of time and also in the quality or content of nutrient constituents therein. Thus five different grasses (in certain experiments in the Punjab) grown under comparable conditions yielded the following quantities per acre *:—

Rhodes grass	.. ..	5·6 tons
Anjan (*Pennisetum cenchroides*)	..	5·4 ,,
Palwan (*Andropogon annulatus*)	..	7 ,,
Dub (*Cynondon dactylon*)	..	2·5 ,,
Chimbar (*Eleusine flagellefera*)	..	1·4 ,,

It will thus be seen that the variation between one grass and another in the tonnage of grass yielded is very large indeed, as there is a difference of something like 400 per cent. between the highest and the lowest yielders in the kinds of grass compared. Similar figures of yields under comparative conditions for certain pasture grasses in South India are as below:—

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*P. E. Lander in the *Journal of Agricultural Research*, Vol. XIII, Part III.

Yields of grass under rainfed conditions at Coimbatore.

Botanical name	Yield.
Chionachne semiter	15,000 lb.
C. Koenigii	15,000 lb.
Sehima nervosum	10,000 lb.
Amphilophis pertusa	80,000 lb.
Dichanthium annulatum	6,000 lb.
Iseilema laxum	5,000 lb.
Eremopogon foveolatus	12,000 lb.
Cenchrus ciliaris	21,000 lb. and under favourable conditions up to 40,000 lb.
Chloris Bournei	56,400 lb.
Panicum maximum	21,000 lb. under rainfed and 50,000 to 75,000 lb. under irrigated conditions.
Panicum antidotale	15,000 lb.
Cynodon plectostachyum	(Giant star grass) 30,000 to 60,000 lb.

Differences likewise exist in the *quality* or composition of the grasses in respect of their content of nutrient constituents, both organic and mineral; but such differences are nothing like so great as in the case of the quantity yielded. Thus in the case of the above five grasses, the average composition in regard to proteins and mineral constituents was as below:—

	Proteins	Lime	Phosphoric acid	Potash
Rhodes grass ..	3·7	0·77	0·52	1·3
Anjan ..	3·8	0·83	0·66	2·5
Palwan ..	3·9	0·50	0·30	1·58
Dub ..	4·27	0·81	0·44	1·14
Chimbar ..	4·6	0·89	0·51	1·21

The greatest and most striking difference however arises only as between the grasses proper (Gramineæ) and the leguminous 'grasses', such as the various clovers and other leguminous plants found in local pastures. Thus while the protein in any ordinary grass may amount to only 7 or 8 per cent. on the average, the proteins in leguminous plants may be double this quantity on the average, and in good samples may go up to even 20 per cent. or more. The larger the mixture of such leguminous vegetation therefore in a pasture the more nourishing it is in quality. In fact one of the chief aims in grass land management, where such management is possible and practised, is to see that leguminous

fodder grasses constitute a fair proportion of the herbage and that they belong to such species as will hold their own in competition with the other components and continue to flourish. This is generally ensured by means of suitable seed mixtures and correct manuring.

The grasses comprising ordinary pastures are very large in number and common belief recognises considerable differences between one and another in the nutritive qualities; thus the grass *Pennisetum cenchroides* called "kola-kattai" grass in Tamil is said to be very nutritious and tending to bring cattle into very good condition; well grown hariali (*Cynodon dactylon*) is likewise credited with similar qualities; conversely, many grasses are considered very inferior, coarse and even liable to weaken and otherwise prove harmful to cattle. There are others which on account of the spiny or very rough leaves or of strong smells, are avoided by cattle and are therefore valueless as fodder. Some of the coarser grasses which are not eaten in normal times are grazed in times of drought and scarcity, when they afford a coarse subsistence diet, but often leading to digestive and other troubles. Chemical analyses of the large variety of different grasses at the same stage of maturity and derived from the same pasture are very few and accurate data in regard to their feeding value are lacking. We give however (see page 25) the names of the principal grasses that compose the natural herbage in the pastures of many parts of India. It is stated that the number of species found in the Madras Province alone amount to 388, of which 82 are recorded as of fodder value. There seems to be considerable correlation between the environmental conditions such as soil, rainfall, elevation and so on and the type of grass or species which is favoured and is predominant, but this very interesting aspect like many other characteristics of pasture grasses, has not been worked out.

(c) *Soil.*—The next important factor influencing the quality of pastures is the soil. The better the quality of the soil both in its content of plant foods and in its physical character the heavier is the grass growth, just like any other crops. With the same amount of rainfall the

growth of grass is much heavier on the loamy, clayey or black cotton soils on the level plains or low-lying areas than on the thin gravelly or stony upland soils of high lying ridges and slopes. The soil influences the yield or quantity of grass in a striking manner, but the effect on the quality of the grass is also very noteworthy though it may not be very striking or obvious. The composition of the vegetative parts, principally leaves, of all plants in mineral constituents varies very much according to the composition of the soil, in contrast with the composition of the seed, which is much more constant and independent of the composition of the soil. The mineral contents of the pasture therefore vary a good deal according to the composition of the soils. The mineral content (ash soluble in hydrochloric acid) may vary within such wide limits as from 2 or 3 per cent. up to 10 or 12 per cent. A deficiency of mineral ingredients makes the grass poor in quality in that respect and such poverty of mineral ingredients may sometimes lead to serious results.

Very often the insufficiency may be in respect of the important ingredients, lime and phosphoric acid, in which case animals which are fed only on such grass may suffer from weak bones and similar maladies, and if they are heavy milking animals, they may suffer seriously in general health. Conversely on soils which are well provided with such constituents the grass is of high quality furnishing excellent feed which maintains the animals in good condition both as regards their general constitution and their milk-yielding capacity. Where relevant studies have been made it has generally been found that the most fertile soils not only yield the highest outturn of grass but also grow the best kinds of grasses and of the best nutritive quality. The total protein in the herbage has been found to be positively correlated with the humus content of the soil while a high lime and phosphoric acid content in the herbage likewise with a high content of these plant foods in the soil.

It is also interesting to note that the soil composition will affect the nature of the vegetation that can flourish on them and therefore the quality or the feeding value of the pasture. A sufficiency of lime in the soil will

usually favour the growth of good leguminous vegetation in the pasture while the lack of this constituent may lead to the growth of only coarse inferior grass vegetation. In a famous and well-known experiment this fact was strikingly brought out ;* on grass land manured with only sulphate of ammonia every year as the result of which the soil became much depleted in lime, the grass had greatly deteriorated, the leguminous plants having been crowded out and only coarse ordinary grasses remained and flourished. The pasture was then divided into two strips and one strip was limed while on the other the old treatment was continued. The result was a striking change in the character of the vegetation in the limed half, which became more and more restored to a good proportion of leguminous plants. The composition of the soil whether natural or as the result of manuring thus influences very materially both the quantity and the quality of pasture grasses. Just as the insufficiency or absence of certain elements in the soil (and consequently in the grasses grown on them) will lead to particular maladies in the stock kept on them, so the presence of certain unusual soil elements will likewise lead to particular diseases or other troubles in the animals feeding on them. Examples of these are the element selenium and the element fluorine. The former leads to 'blind staggers', lose of hair, emaciation and death and the latter to fluorisis which disables animals seriously. More examples will be found under "Pastures and Cattle Diseases" (*vide* page 20).

(*d*) *Interval between Cuts.*—Lastly, the value of pastures is also influenced by the interval of time which elapses between two successive grazings, or in other words, by the stage of growth of the grass when cattle are let in for grazing or when the grass is cut for stall feeding. In the earlier stages of growth the grass is very much more nutritious than in the later stages. Young grass contains a larger percentage of proteins, phosphoric acid and potash in the dry matter than older grass ; the reduction in the percentage of these constituents

* Rothamstead Experiments.

is progressive as the grass becomes older. If the grass is cut at intervals of one month, it is richer in these constituents than if it is cut at intervals of two months, and the latter itself in its turn is richer than when it is cut at intervals of three months. On the other hand, the younger the grass the less is the percentage of dry matter, that is, the more watery or succulent it is. Furthermore if the grass is cut at longer intervals the total quantity of grass itself (on the same moisture basis) is larger than when it is cut at shorter intervals. Thus in the Punjab experiments quoted already, the protein in the grass cut at intervals of one month varied in the different grasses from 6·5 to 8·7 per cent., in the grass cut at intervals of two months it varied from 4·4 to 5·3 per cent. and in the grass cut at intervals of three months it varied from 3·7 to 4·6 per cent. It has also been found that the lime and phosphoric acid existed in a proportion more favourable to milk production in the younger grass than in the older grass, which is another advantage with grass fed young. The interval between grazings thus affects both the quality and quantity, the quantity improving with the age of the grass and the quality going down as the grass grows older.

In practice the value of pastures is judged by the number of cattle they can carry. This however is a varying figure depending upon the nature of the animals concerned, that is, whether they are large or small, cows or buffaloes, milking or dry, young or old, and so on. Whichever they may be, for this purpose it is the quantity of the grass that matters very much more than the quality or composition and, as explained above, the quantity increases as the grass grows and ripens. When the grass is well grown the tonnage it yields is very much more than when it is young and the pasture can therefore carry a larger number of animals than in the young unripe stage. For this reason pastures have to be allowed to grow uninterruptedly to this stage before letting cattle in. This can be done of course only in pastures fenced in and otherwise under control. Open and uncontrolled pastures suffer in their fodder value not only by a reduction in the total quantity of the grass which such

unrestricted grazing brings about but also suffer deterioration in another way. A large number of animals grazing on the tender grass give no chance to the grass to grow, prevent them from spreading and tillering and also damage the physical condition of the field. For these reasons it is advisable and necessary to control the grazing and observe a close season until the grass is well grown.

The matter however assumes a different aspect in the case of pastures or leys which are managed carefully and with frequent manuring in order to obtain frequent cuts of *young* grass. Such grass is very much richer in quality, and with the repeated manurings the total quantity too is very much increased. The grass so obtained is made use of in preparing dried green grass (as distinct from hay) which it is claimed can almost take the place of concentrated feeds like oilcakes. (See also page 53.)

The Village Grazing Grounds and Their Improvement

A word may perhaps be said here on the subject of the *gomals* or village grazing grounds. The thoroughly unsatisfactory condition of these so-called pasture grounds and the need for, and the manner of, improving them are matters which have been frequently discussed ; no tangible improvement has however been effected anywhere nor does it look as if any is likely to be made, as far as we can judge. These pastures are open wastelands, absolutely uncared for, often overgrown with thorny jungle vegetation; the surface is hard, uneven and cut up by many gullies and water-courses which become deeper and wider every year ; the soil is continually depleted by surface wash ; the grass is thin and patchy and the grazing available only for a short period in the year and even then is poor and innutritious; and all the time they are over-grazed and damaged by herds of cattle far too many for the area available. At present they are little more than open spaces serving as the exercising ground for the village herds. The area is under common ownership and every villager has the right to allow his animals to graze or rather to wander freely therein. The way

to improve them has sometimes been cynically suggested to be to improve th n out of existence altogether, that is to say, to give them over for ordinary cultivation and separate individual ownership. This is advised because it is well-nigh impossible to do anything by way of improvement as long as all the land is under common ownership as it is to-day. That of course will deprive the village cattle of any open grazing or exercising ground at all during the crop season when all the fields of the village are bound to be under some food or money crop and none will be left as grazing area by any individual villager. Even if the system of fencing each man's holding and that of growing fodder crops as such should eventually come in—which is a very remote possibility —open exercising ground of sufficient extent will be needed such as is provided now by the so-called grazing grounds. One possible method of meeting the problem will be to strengthen the village *panchayets* suitably and persuade them to develop and work these pastures in a somewhat better way than they are worked now. The *panchayet* may compel each holder to contribute towards improving the pasture by ploughing, cutting down wild jungle growth, filling pits and so on, in labour proportionate to the number of cattle kept by him ; to work the pasture in two sections, one being closed to grazing while the other is in use ; to plant a few shade trees like *babul* which will not be inimical to grass growing under their shade; to plant suitable grasses like Napier or Rhodes grass and nurse it till it is well established, and so on. Many such improver ents can be suggested, which will become possible if only the *panchayet* will or can be persuaded to forego or adapt the joint ownership conformably to the requirements of the method of improvement indicated above. It will be seen that the matter is more a question of village administration than of any special agricultural technique.

Natural Pastures and Their Management

It has been already been mentioned that there are few pastures in India of the kind usually understood by the term in England or other

countries similarly situated, which lend themselves to regular management by well-established methods. The pastures which are to be seen in this country are generally hill pastures, forest pastures, riverside or tank bed pastures, open treeless downs and grassy hill slopes, nearly all of which are under the ownership of Government or village communities and only rarely under the ownership of individual farmers. Obviously under these circumstances it will be well nigh impossible to carry out any measures of improvement or conservation, although the need for such measures is very great. Nevertheless it will be useful to deal briefly with the general objects of such measures and the methods adopted in practice.

Clearing jungle.—The most obvious measure in the generality of cases is the removal of jungle, scrub and thorny vegetation; these take up ground which should be occupied by grass and are seldom of any grazing value ; some indeed may be positively harmful if grazed by accident. Their removal will set free much valuable area for grass and therefore increase its capacity to carry more stock.

Surface improvement.—Many such pastures are cut up by gullies, depressions and pits, while others may present a highly eroded surface. These are serious impediments to the free movement of cattle and from most of them valuable surface soil has been removed by erosion and grass growth is either very sparse or nil. The erosion has a tendency to increase from year to year and if the gullies are not plugged or if other suitable anti-erosion measures are not taken, the pastures shrink in area gradually and the grazing value is permanently impaired. Hollows will have to be filled, large mounds levelled down, gullies plugged by small cross bunds, and in the case of serious erosion regular large-scale protective measures taken. Some of these will result in the formation of small reservoirs or *kattés* where water will stand in the hot weather also and furnish drinking water to the cattle, and increase the moisture content of the soil itself for the sustenance of grass.

The fencing of pastures.—The fencing of farms and other cultivated land is a practice whose importance is

well recognised and wherever possible the farmer usually carries out fencing. In grass land management also the matter is important. Fencing is necessary both for preventing other people's cattle from straying in and also for keeping one's own cattle inside the fenced area. Fencing will also make it possible to observe a close season against grazing, during which period cattle will be shut out and grass allowed to make sufficient growth for affording good grazing, after which cattle may be let in for grazing. Although fencing has to be erected for the whole of the pasture in one block, it will be more advantageous to divide the pasture, if it is large enough for the purpose, into two or more blocks by means of equally good fences. Such division into separate blocks or paddocks will enable one to adopt rotational grazing.

Rotational grazing.—The chief object of this method of grazing is to afford sufficient growth of grass in the paddocks. Pastures which are always open to grazing may afford abundant grazing at one time and little or nothing thereafter. In the former case animals gorge themselves and the pastures are very unevenly grazed, while in the latter case they get little or nothing. Young grass gets no time to grow and establish itself for a good flush later on and at a later stage there is no grass left which will mature and set seed and thereby prolong the life of the pasture by natural regeneration.

The system will also enable one to suit the animal to the quality of the grass, so that animals in milk may have the first bite and the choicest quality, which may be followed by the second grade of animals and thereafter by the dry stock for grazing the paddock closely right down to stubble.

The ploughing and cultivation of pastures.—It will be an advantage to plough pasture lands occasionally, say once in three or four years preferably in strips by rotation. Usually pastures become root-bound so to speak, the soil at the top becoming matted with roots which become too old and serve only to cumber the ground and hinder the development of the sward. The matted surface will have to be torn asunder and the growth of new young roots and stolons encouraged. The ploughing

suitable for this purpose is something akin to the ploughing by means of a country plough and not the soil inverting mouldboard plough. Only a mere cutting through of the sod is to be accomplished and not soil inversion. Even this kind of cutting through need not be a case of thorough ploughing with furrows very close to each other. A good cultivator with strong straight cutting tines will do a good job and may be also a time-saving implement.

The resowing of pastures.—The ploughing may be combined with some amount of sowing of good grasses, if the pasture should be patchy or if the herbage consists of only coarse grasses. Generally the components of the grass population compete with each other and eventually settle down to an equilibrium, when the bulk consists of the hardy ones which are able to survive in this competition. Such survival if left entirely to nature will result in a poor pasture of coarse and hardy grasses ; the tendency therefore has to be counteracted and seeds of better grasses including some legumes have to be sown periodically, at intervals of a few years. Such management will ensure herbage of good quality.

Spreading manure.—Though it is unthinkable that in India manure can be spared for pastures, still the value of the practice should be recognised and if animal husbandry of a high order is to come in at all, manuring of pastures will have to be resorted to. The least which can be done in the meanwhile is to see that the dung voided by the grazing stock on the pastures is left wholly on the pasture and not gathered up and carried home as it is done generally at present. Such dung will have to be spread and scattered over the whole pasture soon after the grazing is closed and not allowed to lie in lumps here and there over the pasture where it was voided. Patchy rank growth will result all around the lumps while under and beneath them growth will be smothered. An even spreading of the manure will prevent such patches and encourage a uniform normal growth over the bulk of the area. Harrowing the pasture will help both in such even spreading and in working the manure lightly into the ground.

The Hohenheim system of pasture management.—The various methods described above and especially the rotational system of grazing, constitute the principal features of what is termed the Hohenheim system. Under this system the following are comprised:—(1) the division of the total pasture into several blocks, preferably by means of fencing; (2) the separation of the grazing herd into two or more classes according to their productive capacity, *i.e.*, for example, the highest milk yielders, the medium ones and the dry animals; (3) grazing the paddocks in rotation by these different classes of animals, the best animals being put into the best paddocks, the second class following these and the dry animals being put in last, in fact suiting the quality of the pasture to the performance of the animals; (4) heavy and special manuring of the paddocks, so as to keep up a steady and luxuriant growth of grass with the highest nutritive value. The paddocks are to be limed first and then given a basal dose of 50 to 70 lb. per acre of phosphoric acid and the same amount of potash. During the growing season a top dressing with 80 to 100 lb. per acre of nitrogen is also to be given, in two or more applications and the dung is to be spread and scattered uniformly after each herd has passed through. It will be seen that this is perhaps the acme of perfection in grazing practices and can be adopted only where dairying is a highly developed and profitable industry, the returns from which will justify such costly measures.

The Burning of Pastures.—Reference may now be made to a system of pasture management which may be said to be the very opposite of the careful and elaborate methods described so far and which consists merely in setting fire to the pasture at the end of the season, generally at the height of the hot weather. Many extensive natural pastures on the plains, forests and hills are systematically fired by graziers and nothing is a more striking spectacle at night in some of these tracts than the straggling festoons of blazing fire to be seen on the distant hillsides. It is a much dreaded practice, on account of the destruction likely to be caused to forest timber and plantations and is strictly forbidden. Neither

preventive nor protective methods avail in these cases, while in the open country and grassy downs and plains it goes on without let or hindrance, and strangely enough, meets with a considerable measure of support. It is the settled opinion of graziers that such burning is the only way in which the pasture can be kept in good condition from year to year, that a good flush of young grass results soon after the rains on such pastures, that there is no other practical way of destroying thorny vegetation, weeds and roots and even the dried up remains of the grass itself, and indeed of cleaning the pastures of all unwanted vegetation, and that the huge quantities of ash which results and the baking of the soil act as fertilizers for an abundant flush of grass. It is moreover one effective method of keeping down the cattle tick pest, on account of which many good pastures become a serious menace, and of destroying other forms of parasitic infestation, insect pests, burrowing animals and the larger kinds of vermin generally, none of which can escape destruction by the fire.

As against these claims in support of the practice may be put down the following:—(1) valuable humus and vegetable debris which will improve the physical condition of the soil are destroyed and though the material burnt up is mostly coarse woody cellulose matter, considerable loss of nitrogen also takes place which would otherwise remain and enrich the soil; (2) that valuable kinds of grasses are not given a chance and are destroyed along with their seed, leaving the pasture to be occupied by the hardy but less nutritious grasses, which are able to survive; (3) the danger to forests and plantations is very great, not only to the wealth of timber of great age but also to the forest cover of tree vegetation of all kinds. In practice, it is this last mentioned risk that weighs most against the practice and since the risk cannot be avoided, reliance has to be placed on efficient watch and ward and protective measures like large and well maintained fire lines, disposed suitably and in ample measure. It cannot be denied that no other means can serve the objects for which the practice is resorted as quickly, and in as cheap and effective a manner. As a matter of fact

there appears to be considerable difference of opinion on the merits of this almost universal and time-honoured practice (or malpractice) the position being summed up by one writer thus, "To burn or not to burn"? Opinions vary from a definite "yes" to an emphatic "no" with a whole range of intermediate views which see burning as a necessary evil, but one to be avoided if at all possible, and in any case to be carefully controlled." (*The Grasslands of Latin America*, by G. M. Roseveare.)

Pastures and cattle diseases.—A number of cattle pests and diseases are the result of cattle feeding upon certain particular pastures. These may be due to parasitic and other insect pests, the quality of the soil, the nature of the vegetation or the situation of the pasture itself. A brief reference may now be made to this feature of grazing land, without however going into the methods of treatment of such maladies.

(1) Cattle ticks. The most common trouble of this kind is the prevalence of ticks. Cattle return from such pastures covered with ticks and however well they may be groomed or the premises cleaned, as long as the pastures are infested the trouble remains. Not only do the animals become much debilitated by the plague of ticks sucking their blood all the time, but they may also be attacked with 'tick fever', and if they are non-Indian breeds or cross-bred stock, may die as the result. As far as the pasture is concerned, burning in spite of its other attendant risks, is one way of getting rid of it, as likewise is the abandonment of the pasture as grazing ground for a season at least. Certain grasses are credited with the property of being able to repel ticks and if they form the major part of the herbage then too it may be supposed to become tick free. The grass *Melinus minutiflora* is mentioned as one such, but it is doubtful if it is really so. It is even credited with the power to repel mosquitoes and snakes, neither of which claims appears to be beyond doubt. As far as the animals are concerned, the universally recommended remedy is to use arsenical dips or the recent sprays with D.D.T. rotenone mixtures.

(2) The 'liver fluke'. Pastures situated in low lying marshy land or on the edge of the waterspread of large

tanks which always contain water become infested with 'liver flukes' and the animals grazing on them begin to suffer from the disease of the same name. There is generally luscious grass in such situations and animals eat it voraciously and infect themselves seriously in the process. Pastures can be freed to some extent by the keeping of ducks, which feed on the hosts (snails) and thereby check the growth of the infection. As far as the infected animals are concerned recourse must be had only to the proper medical treatment.

Diseases due to soil peculiarities.—There are quite a number of cattle diseases which are put down as due to peculiarities in the composition of the soil. The idea is that the herbage growing thereon is much influenced by this composition, the presence or absence of the elements concerned in the soil being reflected in the composition of the grass, leading therefore to a deficiency or excess of such elements in the body tissue of the animals grazing on them. Reference has already been made to some of these diseases (see page 10). The disease called Osteomalacea which causes weak bones and also impaired fecundity, is caused by the lack of sufficient lime and phosphoric acid in the soil of the pasture and consequently in the grass thereon. Other diseases in this class are however brought about by the presence or absence of the so-called 'trace' elements, like copper, cobalt, iodine, selenium, manganese, molybdenum, and so on. It will be outside the scope of this little book to go beyond a bare mention of some of these diseases. Cobalt deficiency is said to be the cause of the diseases called 'bush sickness,' and several other forms of anæmia or wasting away in both cattle and sheep. To a deficiency of copper or copper and cobalt are attributed diseases called 'sway back', 'falling diseases', etc., which affect the nerves and also cause wasting; to a deficiency of iodine the disease called 'goitre'; and of magnesium to the disease called 'grass tetany' or 'grass staggers'. The presence of selenium in the pasture causes 'selenium poisoning' through the diseases called 'alkali disease' and 'blind staggers' while that of the element fluorine to the disease fluorosis referred to already. It may be observed however that

this causal connection between the soil composition and the particular diseases indicated above is not thoroughly established in all cases, many of them being more or less border line cases.

Death or disorders due to vegetation.—Many weeds and bushes on pastures are considered unfit for grazing and even positively dangerous and although cattle instinctively avoid them, accidental grazing with its harmful results is not ruled out. They may do so by accident or because they are driven by hunger. Grass vegetation especially the grass *Paspalum scrobiculatum* and the sorghums contain prussic acid which, under certain circumstances may exist in dangerous concentrations and cause death. It is reported that sorghums which have been partially eaten by locusts is highly dangerous to cattle which may graze on them.

Among other weeds and shurbs which have been found poisonous to stock may be mentioned the following:—*Vicia sativa, Lathyrus sativus, Pseudocalymna elegans, Tanœcium nocturnum, Halocalyx glaziovii, Cestrum parqui, Lochnera pusilla, Rhododendron nilagiricum, Ricinus communis.*

Temporary Artificial Pastures or Leys

So far we have dealt with natural pastures and the methods of management by which their grazing value may be improved. There is however another type of grass land, which though very much less in extent is equally important, and these are what may be called 'artificial' in the sense that they are specially laid out and sown to grasses much in the same way as agricultural crops. They are kept up as such only for a few years which may range from three to five and are then broken up and sown to agricultural crops. In fact, they form part of a rotation, so to speak, in which grass occupies the ground for a period of five years or less and is then followed by a series of field crops in a rotation usual for them, and this series is again followed by grass. Great attention is paid to the preparation of the land, to the selection of the kinds of grasses to be sown, manuring, weeding, and utilising the grass either as such or as dried

green grass or hay, etc. Such pastures are known as 'leys,' usually qualified in addition by the number of years it is due to be kept as such. Though it is an old practice it has come into much prominence in recent years due largely to the work of Sir George Stapleton in the management of leys. Broadly, the ley is so managed during the period that it is allowed to last, that the maximum outturn of the best grass or total nourishment is obtained every year and that, at the end, the maximum of fertility accrues to the soil, which will be used to the advantage of the succeeding series of field crops. There is much in common between the methods of managing permanent pastures and leys but the essence of the ley system consists in selecting the components of the seed mixture sown. Ordinarily (and before Sir George Stapleton introduced his improvements) the seed mixture consisted of both grasses and legumes (or clovers) of many kinds, furnishing both tall growing (or top grasses) and soil covering under growth of grass and legumes (or bottom grass), for a balanced feed, and at the same comprised kinds for the early season, for the mid-season and for the late season. Some seventeen different kinds used to be sown in this way, which had the further merit that they served as a kind of insurance against seasonal variations. As the result of studies of the characteristics of grasses and of different strains therein which revealed how extraordinarily well some did as pure strains, the change was introduced of growing only two kinds, one of a grass and one of clover in the place of the old time multi-mixture and of giving these the best or optimum conditions to grow, such as thorough preparation of soil, manuring and complete freedom from competing weeds. The striking results obtained have made the change very popular and the new method is said to have come largely into vogue. Still, it must be pointed out that the miscellaneous collection of many grasses and clovers and even weeds of the natural pastures or of the old type of leys is not without its advantage. As against the pure herbage of the new leys the former afford a mixed diet so to speak, of grass, for instance, at different stages of growth, different in the content of moisture,

mineral fibre and also perhaps in bovine taste. It is also stated that there is less scope for bloat or tympanitis in the grazing animals on these mixed pastures and that the animals themselves show their preference to it by straying into them from their luxury paddock of the new ley.

The Composition of Indian Pastures

There have been very few studies made of the characteristics of the pasture grasses in India, and data relating to the subject are lacking. Surveys have been made here and there and grasses composing the herbage on many pastures have been listed and some chemical analyses of the individual grasses or the mixed herbage in such pastures have also been made ; but a regular study under comparative conditions of their agronomic, chemical and other features by agrostologists is a great desideratum. A brief reference may however be made to the subject to the extent possible under the circumstances.

Good pasture grasses must posses the following characteristics, *viz.*, they must be (*a*) palatable, (*b*) quick growing, (*c*) be able to withstand or survive much trampling by stock, (*d*) be capable of multiplying in abundance by seeding or by stolons and runners, (*e*) be able to grow on soils of ordinary or moderate fertility, (*f*) be hardy and capable of holding their own in competition with, if not suppressing, poorer but hardy grasses and weeds, (*g*) flourish in association with legumes, (*h*) preferably drought resistant or capable of living through the hot weather and coming up quickly with the first rains, (*i*) afford good soil cover, and (*j*) have a high nutritive value.

The qualities of the innumerable fodder grasses in Indian pastures in respect of the above requirements are very little known, nor is information available as to the kinds and varieties which are adapted to and naturally belong to various environmental conditions like soil, rainfall, altitude, etc. It is not possible therefore to give any list of pasture grasses, together with information regarding their characteristics, which can claim to much accuracy ; nevertheless the following which has been

collected from such sources as are available may be found useful though its limitations should be borne in mind.

The following is a list of the pasture grasses which generally compose South Indian pastures :—

Cynodon dactylon
Digittaria marginata
Heteropogon contortus
Amphilophis pertusa
Dactyloctenium Aegyptica
Eragrostis plumosa
Ischæmum aristatum
Brachiaria ramosus
Urochloa reptans
Echinochloa colona
Chrysopogon montana
Arundinella Metzii
Eulalia tristachya
Panicum repens
Isilema laxum
Chloris barbata
Aristida depressa
Dichanthium annulatam
Schima nervosum
Themeda tremula
Chloris montana
Echinicloa procera
Alleteropsis cimicina
Panicum psilopodium
Perotis indica
Paspalam sc robiculatum
Amphilophis insculpta
Sporobolus diander and spp.

It is interesting to note that among these grasses *Ischæmum aristatum I. Rangacharianum*, *Arundenella Metzii* and *Themeda tremula* are confined to the west coast and the tracts of very heavy rainfall on both sides of the Western Ghauts, that the grasses *Amphilophis insculpta* is predominant in the Nilghiris, Pulney and other high elevation hill stations, and that *Schima nervosum*, *Chrysopogon montana* and *Heteropogon contortus* thrive

in tracts of moderate elevation, that in the famous Ongole cattle tract and the Circars generally the common grass is *Isilema laxum* and that the grass *Cenchrus ciliaris* is confined only to the Coimbatore District.

A map showing the distribution of the pasture grasses in the Madras Province has been prepared and published by K. Cherian Jacob in *Indian Farming*, March 1945, to which readers are referred.

Meadows

Another important source of green grass similar to pastures are 'meadows' which is the name given to grass fields which grow enough grass to be cut or mown regularly and fed to cattle as such or more often dried and converted into hay and stored. This kind of grass land is generally low lying, more fertile and very often capable of being irrigated. Many sewage farms in India which specialise in the growing of grass may be said to be 'meadow' lands. In this connection we may draw attention to one very interesting class of meadow land and grass growing, which prevails in Italy, in certain sections of which country rice growing is carried on along with and as part of dairy farming and milk production. Rice land is given over to grass for a period of three or four years after being under rice continuously for about the same period, so that it is a form of rotation of rice with grass. The abundance of green grass and hay secured by this system of farming has made these tracts important dairy farming sections where milk, butter and cheese and dairy and other types of cattle are produced on a large scale. In addition the rice crop is much benefited by following several crops of grass in this way, the soil is improved and rendered more fertile by the remains of the heavy mat of grass roots and stubble which is ploughed under, in the same way that a ley brings the soil to a high state of productivity, much to the benefit of the succeeding field crop in the rotation. The abundance of irrigation water leads to the assured production of a very heavy tonnage of grass. The maxim there, is "more green grass, more milk" and "no green grass, no milk"—a wise and valuable maxim to bear in mind for all dairy cattle

owners. The practice is unknown in India as far as the author is aware, but in view of what is claimed for it in respect of both the yield of rice and of the production of milk it is worthy of trial for finding out if it can be copied with advantage.

Many sewage farms which utilise the sewage for the growing of grass may be regarded as meadows. In many of such farms whether in India or abroad, vast quantities of both green grass and many other kinds of fodder crops are grown for being fed to dairy cattle. Sewage for this purpose is used either in the raw state or after being treated in septic tanks, the clear effluent being used for irrigation. The question is sometimes raised if the crops grown in such farms can be fed to cattle without any harm ; although on the face of it it may appear rather risky to do so, considering the filthy condition of the sewage, in practice such feeding is not attended with any danger to the animals. In one sewage farm of which the author has experience [the Corporation Sewage Farm in Reading, England] great crops of cabbages, knolkohl, mangolds, turnips, etc., were being raised, using raw sewage itself and these were fed to the dairy herd on the farm systematically without any harm. Where on the other hand, only effluents from septic tanks in which the sewage undergoes purification is used there should be still less fear of any risk. As a matter of fact sewage irrigation for raising fodder is a well recognised method of sewage disposal or utilisation.

II

CROPS GROWN FOR GREEN FODDER

THE growing of crops solely intended for purposes of green fodder is not a common practice among the cultivators in our country. It is not that the importance of green fodder is not understood or recognised but in practice many difficulties exist which stand in the way and which curtail their ability or willingness to grow such crops. Largely, it is due to the supreme need for utilising to the utmost all the facilities of cultivation for the raising of food crops, which as is well known is generally precarious and uncertain even when every possible human effort is made and which is brought about by seasonal conditions which can be neither controlled nor predicted. This applies especially to dry rainfed cultivation, which forms the very large bulk of the cultivation in India, forming as far as Mysore is concerned some 80 to 85 per cent. of the total. Even under irrigated cultivation this primary and all-important need is one of the factors, and certainly the most potent factor, which is responsible for the practice. Crops are therefore grown in the first instance for the sake of the grain or produce; this is gathered for human consumption while the other parts of the crop the straws, husks, and dry stems, alone made use of for feeding to cattle. These are comparatively innutritious but furnish the bulk required, in addition to some small amount of energy which sometimes may be nothing at all. We shall deal with this aspect later on, but would only point out here that this is a means of utilising the bye-products of the farm, which are unfit for human consumption, by converting them into milk, meat or power for the work on the farm. For a satisfactory and sufficient production of these products of the animal system however very much more is required than these bye-products and these are given in the shape of green fodder, grains, pulses, oilseeds and oilcakes in the case of such animals as the cultivator considers worth being fed in that way. The other cattle have to shift as best as they can, and that is only a euphe-

mistic way of describing the slow starvation which they undergo during a large part of the year.

Although green fodder crops are not grown as such, for the better class of cattle at least a certain amount of green fodder is obtainable during the main crop season from, say, August to the end of December or January. In Mysore at least there is a succession of such fodder of different kinds from the fields cultivated with the food and other crops. Thus there is always some grass from the field margins which in Mysore are purposely made very large so as to afford some green grass for cutting or grazing to tethered animals ; there is the enormous quantity of weeds of different kinds removed during these early months of cultivation, which is carried home or fed to these tethered cattle ; there are the thinnings which also afford such feed; there is the practice of top-grazing of the well-grown ragi crop, allowed in order to keep down heavy vegetative growth ; this is succeeded by the fodder jola, which is usually thinly sown in rows in among the ragi itself ; later still, comes the horse gram crop, considerable portions of which are removed in the green stage for green fodder ; later again after the ragi is harvested are the remains of the unweeded grass now full grown ; and last come the green ripe vines or haulms of the *avare* from which the pods both green and ripe have been gathered and which have to be removed from the fields. If the tract is one where there is irrigated cultivation also then there is both at this season and later on during the hot weather a certain amount of green grass to be had from the field margins, and no day passes without the ryot or his wife bringing in a headload of grass at the close of the day. Under well cultivation it is not unusual to grow a patch of some fodder grass specially for the sake of the *kapile* bullocks which do very hard work in lifting water ; and likewise in dry land cultivation also a patch or so of fodder jola may sometimes be seen growing, as much for the use of the ryot's cattle as for sale in the towns and cities. Eked out with the sugarcane tops at the milling season, cotton stems, etc., this green feed for the better class of animals may go on till the end of April. This may be taken as a summary of

the present situation in regard to the supply of green fodder from cultivated fields. The quantities obtained in these ways are very small and thoroughly inadequate to the needs ; a large intensification of fodder growing is necessary and suitable adjustments in farming practices have to come in for securing this end. We shall now deal with the different crops which are or can be cultivated for green fodder. These crops are the following:—

(1) The sorghums of different kinds, (2) maize, (3) some of the other grain crops like oats, barley, Sajje or bajra, and some of the Panicums which can all be and often are grown as green fodder, (4) the special fodder grasses like Guinea grass, (5) Napier grass, (6) Rhodes grass; leguminous fodders like, (7) lucerne or alfalfa, various clovers like, (8) Berseem, (9) senji or *Melilotus parviflora,* (10) sann hemp, (11) guar or gori, various other crops like, (12) sunflowers, (13) peas, (14) agase or *Sesbania grandiflora* and so on. In a separate class come the fodder crops called "roots" like, (15) Swedes, (16) mangolds and (16) turnips, the last three being common only in cold countries though the last *viz.*, turnips, is grown to some extent in Northern India as a fodder crop.

The sorghums.—The sorghums (jola or jowar) of different kinds may be said to be the commonest crop grown as a green fodder. They are grown both as a rainfed crop and as an irrigated crop especially under well-irrigation. They afford a large quantity of fodder consisting of both leaves and stems. When intended solely as fodder which is the case with the varieties of the typical fodder sorghums the seeds are sown very thick, some 80 to 100 lbs. of seed being sown per acre; the result is a very thick growth of crop, the plants are very close to each other and crowded and the stems are very thin, tender and succulent, making it easy of being eaten by cattle without any being wasted. When grown as a grain crop which also forms good green fodder, they are sown thinly a seed rate of 10 to 20 lbs. being common ; they are also thinned out in the course of the hoeing and weeding, so that there is a wider stand of crop and the stems

are rather thick and often coarse and a considerable portion of such stems is wasted. In order to prevent such wastage of green stems it is sometimes usual to force the animals to eat the bottom portion of the stem first and then the portion higher up. All sorghums grow very tall, attaining eight to ten feet in height though thickly sown fodder sorghum is very uneven in height and often lodges on account of the thinness of the stem. The sorghums give only one crop with each sowing; though there may be a small ratoon or stubble crop which is negligible. Under irrigation more than one cut can be taken and in order to obtain a steady supply of fodder in the proper stage, they have to be sown at different intervals in succession. Many sorghums have to be fed with caution; they should not be fed when they are very young, and generally should be allowed to come into earhead before they can be safely fed. The fodder sorghums are not so dangerous as the grain sorghums but even in their case it will be safer to wait till the plants are grown to the above stage. The reason is that in the early stages and under certain conditions (which are not well understood) the plants develop and contain prussic acid which is highly poisonous; there is sometimes more and sometimes less, but the quantities which an animal usually eats will contain enough to prove fatal. Young plants, and plants which have suffered a check in growth from drought are among those that contain the poison and are risky to feed. It is also stated that shoots or new growth from plants which were destroyed by locust attack are likewise poisonous; indeed the development of prussic acid appears closely connected with a retardation or check in growth whatever the cause may be, such as drought, locust attack or even a poor coarse and sandy soil. In any case as a safety measure young jowar should not be fed, and if there is no choice it should be dried well before feeding. If the plants are dried or converted into silage then they lose their poisonous character. The sorghums yield very large quantities of fodder; under irrigation and with good manuring from 10 to 15 tons of green material of excellent quality can be obtained per acre. There are many varieties of the typical fodder

sorghums like "kakki jola", "Nilwa", "Sundhia", etc., suitable for cultivation, in addition to the late season winter sorghum called "bili" or "hingar jola", which though a grain sorghum has stems which are quite sweet to the taste and are considered very nutritious green fodder. Fodder sorghums make excellent material for the making of silage both pure and in mixtures with other fodder plants.

It is a practice much to be commended that the fodder should be prepared by chaffing, *i.e.*, cut into very short lengths before it is fed to cattle. Wastage can be materially reduced if not altogether prevented and the feeding value of the fodder better conserved ; we shall explain this further when dealing with dry fodders, in the case of which this matter is particularly important. Chaffed fodder also lends itself better to mixing with concentrated feeds like powdered oilcake, brans and others. Where such mixtures are given it will be seen that animals clean up their feed completely without wasting even a bit.

Maize as green fodder.—Probably the largest fodder crop consumed green in the world is maize, although in India it is only of very small importance. The crop yields a heavy tonnage of succulent stems and leaves which are in excellent condition as green feed in the stage when it is usually cut in India, *i.e.*, before the cobs are dry and dead ripe. It is fit for green feed and for silage, for which latter purpose indeed it is used almost exclusively in the U.S.A. Even at the young stage it is free from any poisonous constituent, though it is not usual to cut it before the cobs appear. None of the varieties except one or two dwarf varieties tiller and each seed gives only one plant. The crop is cut when the cobs are partially ripe and at this stage the green fodder value is also high, so that ordinarily it is a dual purpose crop, affording both good green fodder and saleable cobs which bring in a cash return. In South India it is grown only on a small scale and mostly as an irrigated garden crop but it deserves to be grown more largely and also as a rainy season crop on drylands. The stems are very much thicker than in sorghum and chaffing is disirable even more with maize than in the case of other crops. An acre

of well-grown crop may yield from eight to ten tons of good green fodder. Like the sorghums maize is also a one-season crop, and makes way for a different crop after it is cut and removed. The crop can be grown practically throughout the year and a series of three or four plots can be sown successively, so that the green fodder may be available all the year through. On the Kirkee Farm, the crop is sown in mixture with a legume, *viz.*, *Cyamopsis psorialioides* in the same way as oats are grown with peas. Both the oat-peas mixture and the maize-cluster bean mixture have been found to be remarkably favourable to milk production. Under very favourable conditions the outturn of green fodder is reported to have gone up to 40,000 lb. per acre on the Kirkee Farm. In the U.S.A. its conversion into silage is universal and no farm in the dairy sections of that country is without its silo tower and the various mechanical appliances required for chaffing and filling the towers, which is done mostly by means of pneumatic blowers.

Bajra or *Sajje* (*Pennisetum typhoideum*), barley, oats and some millets which are the grain crops grown to some extent as green fodder all afford moderate yields of green fodder and can be cut and fed somewhat earlier than the sorghums or maize. They are more leafy, the stems are very thin, and on the whole they involve little wastage and require little or no chaffing. They also tiller moderately, and if cut young more new shoots appear which can be utilised for a second cut. Of 'sajje' there are varieties which differ in many respects, among which are the size of stems and the tillering capacity. The variety which is fancied for green fodder has very thin stems and tillers well. This variety goes by the name of "hullu sajje" (meaning grass 'sajje') on account of its thin grass-like stems. The 'sajje' stems also branch somewhat and though slender are somewhat pithy. The crop nevertheless is grown to a considerable extent for fodder. All these crops are crops of one season and are not left after the close of the season.

Other cereal crops too, such as wheat and ragi, are made use of as green fodder to a small

extent; the wheat may be eaten down almost to a stubble and then allowed to grow like a ratoon and bear seed, while the ragi is allowed to be grazed down moderately when the growth is rather thick and rank; animals are driven somewhat quickly over the field, so that only a certain amount of top grazing takes place.

Oats are being grown somewhat on a large scale on various cattle farms as a green fodder and for this purpose it is usual to sow a mixture of oats and peas, cut them down together and feed the mixture. On the Kirkee Dairy Farm, this is a favourite green feed mixture. Both have to be grown in the cold weather between October and March. On well manured land with irrigation, the mixture is reported to yield up to 25,000 lb. of green material. The mixture can be cut at any stage and if cut before flowering time it can be left over and a second or ratoon crop obtained.

The Special Fodder Grasses

We now come to a class of fodder grasses which are of special interest as they are grown solely for the sake of fodder and not for the sake of fodder *cum* grain. They occupy the field for several seasons if not years, affording cuts at various intervals which may range from four to eight in the year. Examples of these are Rhodes grass, Guinea grass and Napier grass among the introduced grasses and the indigenous *dub, hariali* or *garike* itself. They are grown mostly under irrigation, and in the neighbourhood of towns and cities, where they find a very good sale for cows and buffaloes which are in milk. On the sewage farms of many cities they are the most favourite grasses grown and under the conditions of such farming, *viz.*, the heavy and regular irrigation and the high manurial value of the sewage, very large yields of green grass are obtained. They all tiller abundantly and with every cut throw out more shoots, so much so that they grow in great clumps (or tussocks) each about nine inches to a foot across. They have indeed to be broken asunder at frequent intervals and suitably thinned out for facility of cultivation. In the case of the *hariali* the

Napier Grass grown in the Indian Dairy Research Institute Farm, Bangalore.

—Photo by courtesy of the Director

Guinea grass grown in the Indian Dairy Research Institute Farm, Bangalore.

—Photo by courtesy of the Director

ground becomes covered with a mat of roots and creeping stems and at the end of each year has to be cut through with the ordinary country plough or cultivating tools with sharp cutting edges which will cut and tear the sod.

The *hariali* grass is an extraordinarily hardy grass. It is very deep-rooted, spreads rapidly, can survive very close grazing and much trampling by stock. Even scraping off of the above ground parts which may kill other grasses outright does not affect its life. It may appear to die down in the summer, but this is only superficial ; it will come up with the first rain with surprising rapidity. It is almost ubiquitous, being the most widely prevalent pasture grass, with the exception perhaps of the regions of torrential rainfall like the Malnads of Mysore or the Western Ghauts and Malabar. It is generally believed to be one of the most nutritious of grasses and may indeed be deemed the best. In addition to being the most favourite green grass, it makes first class hay.

The *hariali* grass gives a very thin-stemmed grass; it may indeed be said to be almost entirely leafy. The Rhodes grass comes next in this respect, the stems being very thin, leafy and attaining a height of some 18 or 20 inches, before it flowers and a height of 30 inches or 3 feet when it begins to head out. The Guinea grass ranks next, with stems much thicker than either and considerably more leafy. The Napier grass has a much thicker stem and may indeed be compared with very thin jola stalks. There are two varieties of this grass, and one of them is really a thick-stemmed grass, with stems as thick as ordinary jola, which in this respect it closely resembles ; it grows very tall with thick stems, long internodes, profuse tillering and thick abundant growth ; the variety is called 'elephant grass' on account of its size or because (as it is sometimes stated) elephants can brouse in it unseen. The dwarf variety is however much smaller in size and can be compared to clumps of spear grass roughly in appearance. The thicker and more numerous the stems the greater is the likelihood of wastage in feeding and the greater is the need for chaffing for preventing such wastage. All the above grasses other

than the Napier grass are therefore very economical feeding and involve practically no wastage.

The very thin-stemmed grasses which are also highly leafy like *hariali* and Rhodes grass can be dried and converted into hay and stored. They are less fit for the making of silage, except when they have begun to seed, at which stage the stems become somewhat fibrous and strong. On the other hand the Napier grass lends itself to the making of silage very well, but is much less fit for making into hay. The Guiena grass may be said to be intermediate between the two classes, in respect of hay making or ensiling. None of these grasses are harmful to feed at any stage ; they are not cyanogenetic and can be safely fed, even when they are young and tender, although for reasons already explained such as quantity and quality they are cut only when they are well grown.

In deciding as to when the grass is to be cut it is well to remember that grasses like other vegetation continue to grow and assimilate food materials from the air and the soil until the time that they begin to head out and flower ; from that period onwards, there is a transference of the food material already stored in the leaves and stems into the ripening grain and the further addition of food materials in the former comes almost to a standstill. There is nothing to be gained in allowing the grass to remain on the land further ; on the other hand the stems and leaves are likely to become reduced in digestibility by becoming more coarse and woody. The stage to cut is therefore about the time that the grass has well headed out and flowered. This will ensure the highest quantity of food material consistent with easy digestibility. One of the most important characteristics of green grass of all kinds is the succulence and freshness and their approximation to the natural food of cattle, and the cut grass should not suffer in these respects to any great extent.

The quantity of green grass that can be obtained per acre from each of these grasses differs not only as between themselves but also in each case according to the soil, manuring, irrigation and other attention it may have received. They can be raised by sowing seeds or by planting cuttings. In the former case the first cut may

be ready in 2 or 2½ months and in the latter in 1½ to 2 months ; depending on the manuring and the irrigation six to eight cuts may be taken in the year. Yields are very heavy though they may vary much. We have already stated that grown under comparable conditions the Rhodes grass gave about 5·6 tons per acre while the *hariali* (*dub*) grass gave only 2·5 tons. Under sewage irrigation Guinea grass is reported to have yielded about 25 tons per acre in the course of six cuts taken in the year, and Rhodes grass under similar conditions to have given from 25 to 30 tons an acre. Napier grass can yield under sewage irrigation enormous yields up to even 80 tons an acre ; a good proportion however of this grass comprises coarse and somewhat woody stems which are mostly untouched and therefore wasted by cattle. Every now and then some foreign fodder grasses are announced and put under trial and also recommended for cultivation ; but few or none have persisted. Among the most recent may be mentioned the Giant Star grass (*Cynodon plectostachyum*) and Kikiyu grass (*Pennisetum clandestinum*). It is significant that the Kikiyu though claimed to be drought resistant, has become established only in the cool hill regions of Nilgiris, Kodaikanal and Anamalais.

An exotic grass of recent introduction which has established itself well and is now an important fodder grass in Bangalore is Para grass or Mauritius grass (named variously as *Panicum molle, Panicum purpurascens, Panicum equinum, P. paraguayense* and others). It has been found to flourish and revel in moist situations, like the beds and margins of tanks, water courses and similar places almost of the character of marshy land. It is a thin stemmed grass of semi-creeping habit, highly leafy and succulent, and reaching a height of 3 to 4 feet; both stems and leaves are well relished and eaten by cattle. It can be grown by the sowing of seeds or by the planting of cuttings and under irrigation gives the first cut in two months. Some 8 to 10 cuttings are taken in the year, reported to yield from 46 to 50 tons altogether. It is kept on from year to year in the same way as Guinea of Rhodes grass, with more or less the same method of cultivation.

Leguminous Fodders

The leguminous green fodders are sharply distinguished from the cereal grasses by the fact that they are richer in proteids, the constituents which really determine the money value of any particular feed. The content of proteids in the leguminous green fodders may be even twice the quantity contained in a grass fodder of the same stage of ripeness. These fodders can, to some extent, take the place of costly concentrated feeds and in any case are eminently suitable for supplementing ordinary grass fodders, so as to bring up the nutritity ratio to a higher level. They are generally fed in conjunction with the latter and not entirely by themselves.

Like other crops in India the leguminous green fodders are grown partly for the sake of the pulses they produce and partly for the sake of green fodder as already mentioned. The few that are sometimes grown solely or to some extent for fodder purposes may now be referred to.

Lucerne (*Medicago sativa*) called alfalfa in the U.S.A. is about the most extensively grown leguminous fodder crop of the world. In India it is grown only on a small scale and in the somewhat cool climate of places like Bangalore, Poona, etc. It is grown more for the sake of horses than for dairy cattle and for the latter it should be called a luxury feed. On some Government farms and around certain cities however it is being grown largely and used as a regular green feed for milking animals also. Although it is thus more or less a luxury fodder in India, it is the most important and extensively grown fodder crop in the U.S.A. where millions of acres are grown. It is fed green, or cut and dried into hay and even ground into a meal to be fed either by itself or in mixture with other suitable feeds. It may indeed be said to be the fodder which forms the very foundation of the cattle and dairy industry of that country.

The crop is grown as a semi-irrigated garden crop in India and requires much care and attention. The field has to be well prepared, laid into beds suitable for irrigation and

for adequate drainage and then sown; the seeds are very small and have a hard surface and on this account they are rubbed with coarse sand to abrade the surface a little and then are sown broadcast or in shallow furrows about 9″ to 1′ apart at the rate of about 12 lbs. per acre. The crop comes up thin at the beginning but soon tillers, the tillering also increases after the first cut. The first cut can be taken after 60 days just when the plants begin to flower here and there on the fields and about 9 to 10 cuts can be taken in the year. After each cut, the field should be hoed and weeded and at intervals of three or four months also manured. The crop is left to grow for two to three years after which it is allowed to seed and is removed when the seeds are ripe. The plants usually grow to a height of 18″ or 2′. The crop may be kept on longer also but many plants begin to die here and there especially when there is too much moisture and the field becomes too patchy. About 20 tons of green material can be expected per acre, though even double the quantity can be obtained under good conditions. On the Kirkee Farm during a period of 2½ years the average yield per acre is reported as 1,72,900 lbs. of green material. About 15 lbs. per day per animal is fed on this farm along with other green fodder, silage and dry fodder.

Lucerne of the variety called "dry land lucerne" was tried in Bangalore on the red loam soils and grown as a dry crop in the rainy season but it was not able to survive the hot weather following. In the black cotton soils it may have a better chance.

Berseem (Egyptian clover, *Trifolium alexandrinum*) is another legume which is grown to some extent on a field scale in Upper India and is gaining some importance. It is grown in rotation with rice and sugarcane and is a semi-irrigated crop much like lucerne, though it does not require the same degree of attention. It is moreover only a seasonal crop and not allowed to remain on the field for more than a season. It is a cold weather crop, the season extending from October to April or May. Seed is sown broadcast at the rate of about 40 lbs. per acre, in the prepared soil or even in the standing crop

of rice, shortly before the latter is to be harvested. The crop grows to a height of 18" to 2', and can be cut four or five times in the season, giving a total yield from 25 to 35 tons of green material.

In the same way as Berseem Clover, other clover-like plants such as Senji (*Melilotus parviflora*), Shaftal (*Trifolium resupinatum*) and even fenugreek are grown as green fodder to some extent especially in the Punjab and the N.W.F. Provinces under well or channel irrigation. Quite a third or fourth of one's holding is said to be put regularly under such crops—a practice which deserves to be taken up in South India also. It is probably the main reason for the pre-eminence of Panjab in milk production.

Sunnhemp.—Though sunnhemp is grown principally as a fibre crop and to some extent as a green manure crop it is sometimes grown as a green fodder crop as well. The crop is grown in rice fields with a little irrigation like a preparatory green manure crop and also as a dry crop in the rainy season. For green fodder it is sown very thick, with some 50 lbs. of seeds per acre and a close stand of thin stemmed leafy growth is encouraged. It is cut just when the plants are about to flower but even before this stage, portions of the field are cut and fed. It is also cut and dried into hay and stacked in alternate layers in rice straw stacks and later on animals are fed with this mixture of hay and straw. The crop occupies the ground only for eight to ten weeks when grown as fodder.

Cowpeas (Vigna catiang).—This is another leguminous crop which is sometimes grown solely for fodder usually mixed with maize as already stated. The mixture is grown in the S.W. Monsoon rainy season when higher yields are obtained than when grown in the hot weather. About 8 lbs. of seed are sown per acre (in the mixture); in the rainy season; the cowpeas make heavy tangled growth sometimes even choking the maize crop.

Pillipesara (Phaseolus aconitifolius).—This is a semi-creeping legume, grown either by itself or more often as a mixed crop. As a fodder it is very suitable for growing by itself. It covers the ground like a mat and can

be grazed or cut, and can be allowed to occupy the ground for a whole year or two. It is very hardy and drought resistant and suits even poor soils, although heavy growth can be obtained only on the better class of land or black cotton soils. The field may be prepared roughly and the crop sown in the rainy season at the rate of about 5 lbs. seed per acre. Yields of green fodder may amount to 6 to 9 tons per acre.

Peas (Field Peas).—This leguminous crop is also grown solely as green fodder to some extent, in addition to its large cultivation for the sake of the seed. In both cases it is generally grown as a mixture, as already stated along with oats in the first case, and along with wheat in the second case. The cultivation is confined to the cold weather season commencing from about October. The oat-pea mixture is sown at the rate of 30 lbs.; yields on the Kirkee farm where this mixture is grown on a large scale and well manured and irrigated have amounted to 17,000 lbs. per acre on the average while heavy crops have yielded at the rate of 25,000 lbs. of green material. The field pea is somewhat semi-erect (as distinguished from the garden pea and has coloured flowers, unlike the latter which have white flowers). The mixture has been found very favourable for milk production and has a high nutritive value, the nutritive ratio being 1 : 5.

Guar (Cluster bean, *Cyamopsis psoralioides*).—Another minor leguminous crop raised to a small extent solely for green fodder is guar, especially the Punjab. The tender fruits are a favourite vegetable and the crop is raised mainly for this purpose, as a garden crop. It is also cultivated for the sake of its seeds, like other pulses, for green manure and for green fodder. As a rainy season crop it is grown as a spare mixture with juar or bajri, and when cultivated for fodder it is grown either pure or mixed with the above in a larger proportion. Several varieties exist, a dwarf thin-stemmed one, and much-branching one, a medium tall one and a very tall one which may reach 10 ft. in height. The latter also bear fruits much larger in size than the former. The thin-stemmed varieties are preferred for fodder. When grown pure about 10 lb. of seed are sown per acre and for

green fodder the plants are cut down when the first pods are forming ; the plants however bear a succession of flower clusters and if left will go on bearing for a long time. The seeds differ from other pulses in that the starch from the flour possesses very high colloidal properties.

Mention may also be made of the leaves and tender stems of the Agasé (*Sesbania grandiflora*)—a crop which though it may not be grown solely as a cattle feed is in considerable use for this purpose. Leaves and branches are cut both from young plants and large grown-up trees and are sold as green feed. This is also a leguminous fodder and is comparable with lucerne. There is also a belief that this fodder has the property of increasing the milk yield of the cows and buffaloes fed on it, although one does not know to what extent this belief is well founded. Chemical analysis however shows that it is a very nutritive fodder. Here is the analysis of one sample : Moisture 76·7 ; Protein 8·4 ; Fats 1·4 ; Carbohydrates 8·2 ; Lime 1·6 ; Vitamin A, 9,000 units (Aykroyd). Its content of proteins, lime and vitamin A is very noteworthy.

Other Non-Leguminous Green Fodders

Sunflower.—The sunflower crop is an important fodder crop in certain countries, and large areas are cultivated. It is a quick growing crop and yields a large bulk of green leaves and stems for use as green feed. It is fed green or is converted into silage in mixture with maize, juar or Napier grass. Its use for silage is however the more important. When it is allowed to grow until it is fully in flower it attains a height of 8 or 10 ft. with thick stems and affords a heavy bulk of fodder. At this stage the lower stem becomes almost woody and the lower leaves become yellow and dry. The crop has to be chopped fine and then filled into the silo. At a young stage animals will consume the green crop without wastage and it is then useful as a green feed. When ensiled the leaves become black and shrivel and do not contribute much to the bulk of the material. The crop is grown also for the sake of its seeds, which yield an important edible oil ; the seeds are also fed direct to poultry. The stems form a valuable source of cellulose.

Teosinte (*Euchlanæa mexicana.*)—This crop which closely resembles maize is a green fodder crop of some importance in other countries and has been tried in India also. Unlike maize it is a crop which tillers abundantly. It is cultivated in the same manner as maize, generally in the rainy season. On fertile loams and with heavy manuring it grows somewhat like maize but under ordinary cultivation it does not attain much height and looks like a stunted or dwarf variety of maize. It can be cut several times in the season and good yields are reported to amount to 19,000 lbs. (on the Koilpatti Farm), while moderate yields to about 12,000 lbs. (Hosur Farm). The stalks are thinner and less woody than maize and the crop can be made use of as green feed or for silage just like maize.

The Root Crops.—The next and last among the kinds of crops grown for cattle feed are the so-called root crops.

These are turnips, swedes and mangolds (or mangels) and to a much smaller extent carrots. The first two are very much like the radishes grown in our country and the third is closely allied to the sugar-beet. As feed for cattle, both dairy cattle and beef cattle, the last one, *viz.*, mangolds, may be said to be the most important. Its chief merit is the fact that it forms the bulky succulent feed, somewhat similar to the green feed of various kinds, which is available in winter, a season in which no crop of any kind can be grown. The crop is of great importance in British agriculture and in fact but for the cultivation of the mangold crop in that country its highly developed animal husbandry, which is that country's pride, would be impossible. In contrast with the crops considered so far the root crops are highly watery ; in fact the moisture content may go up to even 90 per cent.; but the merit of mangolds as a succulent winter feed and as the only one available for the purpose confers on it an importance quite disproportionate to its composition. In this connection I may perhaps relate an anecdote which shows how highly it is held in the farmers' estimation. At the Dry Farming Congress in Colorado Springs, U.S.A., many years ago, which I attended, the Minister for Agri-

culture for the Province of Alberta (Canada), stressed the importance of practical experience in farming as distinct from mere scientific knowledge, by holding up to ridicule the conduct of one of his agricultural graduate lecturers at a farmers' meeting who while explaining the composition of various cattle feeds, characterised mangolds as little better than water, whereupon an irate old farmer got up and thundered that mangolds may be little better than water but that it was d—d good food for cows! The dry matter in mangolds will vary from 10 to 12 per cent., out of which quite 9 per cent. is made up of carbohydrates. Neither mangolds nor the other roots have any importance as far as India is concerned except in a very small way, under the conditions existing in the extreme north and north-western parts of the country.

III

HAY, SILAGE AND DRIED GRASS

The Conservation of Green Fodder or "Preserved Green Fodder"

We now come to what may be called "preserved green fodder"; that is to say green grass and similar feeds treated in such a manner that they can be kept stacked and stored for a long period without losing their main nutritive value as green feed. Three methods are available for this purpose, *viz.*, (1) drying in the sun, and (2) preserving as such, but out of contact with air, (3) drying young green grass in artificial driers. The first method yields what is called Hay and the second method Silage—sometimes (but wrongly) also called Ensilage, and the third method yields dried young grass, which is a product very much richer and more digestible than hay and which is now coming much into vogue. All the three methods of preserving presuppose or imply that sufficiently large quantities of green grass are available over and above what may be required as green feed for the daily needs of the animals to warrant its being preserved in one way or another. Such a state of affairs unfortunately exists scarcely anywhere in India, with the rare exceptions of a few grass farms here and there. The general condition is one of acute and serious shortage of green fodder, and the question of surplus seldom or never arises. Still the general importance of these fodders and the fact that conditions may arise when the making of such products is found desirable, demand that the subject should be dealt with at least briefly.

Hay.—The making of hay consists in first cutting the grass, then allowing it to dry thoroughly and uniformly, and then removing it from the field and stacking it, either as such or after baling. The quality of the hay will depend upon the degree to which all the stages have been gone through correctly. What has been said with regard to the stage when grass should be cut so as to yield

the maximum in both quantity and quality applies equally well to the stage at which it should be cut for hay; that is to say, the grass has to be cut just when it is in full flower. The time of cutting has also to be when a good uninterrupted period of bright sunny weather is likely to prevail for several days after the grass has been cut, so that the hay may not be caught in the rain as it lies drying in the field. The hay loses in quality if it becomes wet, because changes take place in the cut grass which render some of the food materials contained in it easily soluble in water and therefore liable to be washed out and lost, if rain falls on it. More than even this loss is the practical difficulty and inconvenience in drying it satisfactorily. "Make hay when the sun shines" is a maxim to be followed for more reasons than one. For satisfactory drying in the field the cut material has to be turned over, heaped up and shaken several times until drying is complete. In grass containing any large mixture of leguminous and similar fodder plants, overdrying results in the leaves being knocked off, broken and likely to be left on the field when the hay is being collected to be removed to the barn. The protection of stacks against rain is an important requirement and for this purpose sometimes substantial barns are provided. In the countries where hay making is an important practice, a variety of machines, either horse drawn or tractor drawn, are employed for cutting, making into heaps, turning over, shaking, loading, stacking, baling and so on.

The composition of well-made hay is practically the same as that of the grass from which it was made, calculated on the reduced moisture content. If the grass was cut after the flowering was largely over and the grains were beginning to form, then a certain amount of ripening may take place during the hay making, and the stems may increase slightly in coarseness; likewise if the hay became wet in the rain that had fallen on the hay then also the hay may be poorer to that extent. Hay may also become mouldy if left on the moist ground without being heaped, turned over and shaken, or if stacked before the drying was complete. Hay during storage also undergoes changes which result in a reduc-

tion of the dry matter itself; although on the whole it may be said that hay is only grass with a much lower water content and therefore much more concentrated in its nutrient constituents than grass, still as compared with the quality of grass from which it may have been made, there is always a loss due to the various causes mentioned, which though very variable according to the care exercised in its preparation. is fairly considerable and is generally put down as 15-20 per cent. in dry matter, 36 to 60 per cent. in starch equivalent, and 25 to 60 per cent. in digestible protein, and nearly the whole of the carotine. (W. Holmes, Hannah Dairy Research Institute.) On the whole it may be said that hay is grass with a much lower water content and therefore more concentrated in its nutrient materials than the grass. Here is the composition of ordinary hay which may be compared with the composition of green grass given alongside: —

	Water	Albumin-oids	Fats	Carbo-hydrates	Fibre	Ash
Hay ..	15·0	9·4	2·6	38·8	28·5	5·7
Grass ..	68·8	3·4	0·9	14·0	10·8	2·0

The term 'hay' is also applied to the dry grass collected from jungles or forest plantations. This hay is made up only of the dried remains of jungle grasses which have grown to maturity, ripened and shed their seed, and correspond to what will be called 'straw', if it had been a cultivated grain crop. A great deal of spear grass hay is of this type, and much forest hay is also of the same quality.

As an abundant growth of grass, at all warranting the making of hay, takes place only during and before the cessation of the monsoon rains, it becomes almost impossible to make use of this grass for hay-making, on account of the uncertain weather. The grass will have to be left over until the rains completely cease and by that time the grass is over-ripe and unfit for 'hay' proper. Contrary thus to what one would suppose in a country of powerful sun like India, the making of good hay in the areas of surplus grass is not so easy as it may seem. In foreign countries, however, where animal hus-

bandry has assumed great importance and grass is preserved as hay, even when the weather is not favourable for sun-drying, hay-making is carried on with artificial heat, and under cover, the expense and trouble of which are warranted by the importance of the product.

In a small way fodder jola, sunnhemp and the haulms of groundnuts are dried and converted and stored as hay, and to these the remarks about deterioration by rain and the need for protection against it apply and have to be taken note of. In the tracts where the cultivation of the short-season groundnuts (Spanish and Small Japan) is of importance large quantities of haulms fit for making into hay are available but even here on account of the prevalence of rains off and on, the drying becomes difficult ; the practice of drying it to the extent possible and stacking it in the midst of and inside the stacks of straw which is in vogue is one worthy of more general adoption. We have already referred to the practice of preserving dried sunnhemp fodder in alternate layers inside stacks of rice straw, which prevails in the Northern Circars as likewise worthy of adoption.

2. *Silage.*—The second method of preserving green fodder consists in converting it into Silage. For this purpose the grass is cut at the proper stage as for green fodder or hay and is stored whole or in a chaffed condition in such a way that the material is kept out of contact with air. For storage with this end in view, large cylindrical tower-like structures made of brickwork, stone, wood or metal which are constructed above ground or partly above ground and partly below are employed. The storage can also be made in ordinary pits of sufficient depth, width and length, in which the material can be packed and filled and kept well covered over with earth. These are called pit or trench silos, while the former class goes by the name of silo towers. The material may even be put up in well packed stacks, without resort to either of the above two kinds of silos. The exclusion of the air is effected in all the cases by the sides and top of the silo, by the tight packing and by the weight of the material itself, which in the case of the trench silo is supplemented by the layer of earth used for covering.

The more effective such exclusion of air, the less is the loss and the better the silage, other things being equal. Packed and preserved in this manner, the stored grass undergoes considerable change in composition. A great deal of heat develops due to the fermentation which takes place, and the carbohydrate and cellulose materials undergo oxidation and become reduced in quantity. The heat also dries up the mass which also leads to a reduction in weight. Various acids like lactic, acetic and even butyric acids may also form, especially if the temperature is not allowed to rise much, in which case the resulting silage goes by the name of "sour" silage. With vigorous fermentation in the initial stages and the higher temperature which develops, as a consequence, further changes are arrested and a silage somewhat pleasant smelling results which goes by the name of "sweet" silage. The proteid materials also undergo change which may result in some reduction in the digestibility of the nitrogenous compounds. In case there should be a large mixture of leguminous plant material in the grass then ammonia may be formed and a loss of nitrogen may take place. The silage is left in storage for at least two months before it is taken out for feeding; but it can be kept in the silo undisturbed for a very long time, even for some years provided it does not come into contact with underground water. There is a story current in Mysore that pit silos filled during the days of Sir Mark Cubbon's Sheep Farm, were come across many years after the Farm was closed and that the silage in them was found in good condition. One may believe it or not, but if it should be true then it is a remarkable case indeed.

Many kinds of edible green material can be used for making silage. Pasture grasses of all kinds, fodder crops like green juar, maize, bajra, oats, many kinds of weeds, cowpeas, sunnhemp, and similar legumes, sunflowers, sugarcane tops, and even many forest tree leaves can be used. It is however the grasses and cereal fodders like juar and maize that make the best silage. The leguminous fodders cannot be used by themselves but will have to be used only in mixture with the cereal and other grasses proper and even then in only a small proportion.

The others can be used by themselves but are preferably used in mixture with the grasses.

Before putting into the silo the materials are usually cut into small bits or passed through a chaff cutter. This is a great advantage, as it helps to pack the silage tight in contrast with stuff put in whole. In the case of the long stemmed stiff material like maize or juar, or sunflower plants or sugarcane tops, the chaffing is a great advantage. Still it is not indispensable ; they can be put in whole, or cut into longer bits and not chaffed, provided they are laid down properly and packed thoroughly. The tight packing is necessary for excluding air. Usually they are put in as such with no addition of other ingredients ; but sometimes common salt is sprinkled lightly as the packing progresses, in the belief that it helps to make the silage more palatable. The practice is however rare and in any case is by no means necessary.

In a somewhat new method of silage making, dilute sugarcane molasses are added, in a similar manner as the filling goes on. This is found to be a great improvement and serves in a general way to correct deterioration which may occur owing to insufficient packing or the use of an undue proportion of leguminous crops or leaves, the action being due to the development of more acids. As a matter of fact in one process (A.I.V.) dilute acid itself, sulphuric or hydrochloric, is used in the same way. When silage was attempted to be made from sunnhemp, for example, the author found that the silage when taken out was smelling strongly of ammonia and that animals would not touch it. Similar action also ensues when the proportion of legumes is high in the mixture.

As already stated silos can be built either like towers above ground, or partly below and partly above ground, or merely pits, like circular wells or rectangular trenches may be dug for the purpose. The latter type, though not as good as the former, is serviceable enough and fairly efficient if the cost of construction is also taken into consideration. It is the one which is generally recommended therefore in India. Of course in the case of these pit silos it is absolutely essential that the ground chosen

is rather high, of hard soil and not open to any percolation of water. For the same reason they have to be protected against any surface water flowing in also. The capacity of such silos (using chaffed material) 10 ft. in diameter will be 9 tons for a depth of 10 ft. and 23 tons for a depth of 20 ft. In the case of trench silos 6 ft. in depth and with such length as may be given, a cubic foot will hold 23 lb. or even 30 lbs. after the silage has packed tight and well settled. The filling of the silo pit must be done preferably in instalments, so that each day's quantity may be packed tight; such instalmental packing results in a tighter pack than if the packing was taken up after the whole pit is filled. The required pressure can be applied by men trampling the mass, or oxen being driven to and fro, or well laden cart drawn over it many times, or even with an elephant being used to trample it down, according to the convenience or facility available. It does not hurt if there should be a rain during the time, provided no water flows into the pit. The pit is packed with stuff up to some three feet above ground and left; it then sinks almost to ground level in a few days. More stuff may now be put in, if necessary or the whole covered with a layer of straw, leaves, etc., and then covered over with earth and well plastered over with wet mud. It will sink again a little and cracks may be seen in the plaster which should be covered afresh. When made finally they look like long low mounds, well protected against rainwater flowing in by a low bund all around.

When they are opened for taking out silage for use, in the case of these long trench silos, they should be opened from one end, about two or three feet in length and the mass taken out as required until the bottom is reached and then a further length opened and worked in a similar manner down to the bottom and the whole pit used up gradually in this way. There is usually a great deal of spoiled material on the top and on the sides and lastly at the bottom, which is all unfit for use. This loss is to some extent unavoidable and its amount varies according as the filling was done efficiently or not; it should in fact be the aim of the process to keep this loss as low as possible. The loss in weight inclusive of the

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loss by driage due to heat, may go up to 30 or 40 per cent. of the weight of the green stuff put in.

The following figures show the losses in individual pits:—

Trench Silos:

Dimension of silopit in ft.	Quantity of Green Material put in lbs.	Silage Recovered	Loss Actual	Percentage	
60×8×6	107096	67804	14775	13%	Juar, Maize & Sunflower plant sused
40×8×6	48076	37580	10496	22%	
40×8×6	37805	23665	15150	40%	
Circular Silo	*tons. lbs.*				
20′ deep × 10′diameter	20–980	18–0	2–980	10%	Juar and Maize used
25′ deep × 10′ diameter	30–1574	24–289	6–1285	21%	
30′ deep × 12′ diameter	14–334	24–1210	2–1364	17%	

(Figures relate to the Hebbal Farm, Mysore State)

As against hay, silage is a succulent fodder which is an all-important consideration in the case of animals in milk.

The composition of silage as compared with that of the grass from which it was made is interesting and is as below:—

Constituents of green oats and silage therefrom:—

	Green oats	Silage ordinary	Silage with addition of molasses
Moisture	75·05	75·05	75·05
	Per cent. on dry basis		
Protein	9·06	6·68	7·03
Fat	1·94	2·09	2·28
Carbohydrates	76·28	75·15	78·72

In pits which were packed tighter (pressing in several instalments) the silage was of still better quality, both in

ordinary silage and in the molasses treated silage. (Malik Fazl Hosain in *Indian Farming*, April 1945.)

The well-made silage is a pleasant smelling succulent fodder which cattle eat readily, and which for milking cows is found to be even better than green grass. The fact that silage can be prepared even when there is rain and that bright weather is not essential as in the case of hay is a great recommendation in its favour. It is a method of preservation eminently suitable for preserving the large surplus of grass which becomes abundantly available during the rains and also for preserving green fodder which is raised easily in the rainy season. Such preserved grass in the form of silage will serve the all-important need of a succulent fodder during the hot weather months.

Ordinary silage made from maize or juar will have the the following composition:—

	Water	Albuminoids	Fats	Carbohydrates	Fibre	Ash
Maize Silage	81·9	·8	·2	9·4	5·5	2·2
Juar Silage	60·5	1·9	·7	21·4	11·3	4·2

About 30 or 40 lb. of silage is the quantity allowed per cow as a day's feed or roughly 5 lb. for every 100 lb. of live weight.

3. *Drying young grass in mechanical driers.*—The third method relates to the drying of young grass. The type of grass concerned in this method is cut at a much earlier stage than it will be, if it is to be cut for hay. It is, in fact, previous to the flowering stage or what is called 'the long leaf' stage, whereas for purposes of hay the grass is cut after it is fully in flower and even when the seeds are filling. At this pre-flowering stage the grass has firstly a high protein content; further, it is capable of being cut several times, and between two cuts the field is heavily manured. The total yield of grass is therefore more than in the case of hay which admits of only one cut (although there is some aftermath as well). As against these advantages, there is the fact that at this early stage, (in those climates) the weather is unsuitable for open air drying and the use of artificial driers is absolutely essential. Even at hay making time the weather there

is uncertain and some risk has to be incurred or drying conducted under cover or in other ways ; it is much worse at the early part of the season and drying without mechanical driers is unthinkable. There are many kinds of mechanical driers which have been designed and have now come into use but we cannot go into the principles or details of such driers here.

Comparative figures for yields from fields cut for hay and for this special type of grass are reported as below:—

Comparative yields of starch and crude protein from different crops

	Yield of crop per acre, cwt.	Yield of starch equivalent per acre lb.	Yield of crude protein per acre, lb.
One crop of hay from temporary leys	28	1,100	280
One crop of hay from permanent pasture	20	670	170
Dried grass (cut three times)	50	3,400	820

The strikingly high yield of protein is the most noteworthy feature, for it means not merely more grass but very much better grass; in fact the material is considered rich enough to take the place of imported oilcakes in England.

IV

THE DRY FODDERS—STRAW, CHAFF, ETC.

If we leave aside green grass, which is the natural feed of cattle, the commonest and most important fodder and indeed the sheet anchor of cattle feed in India, is furnished by the straws of different kinds. These form the main feed of cattle and provide the large bulk which is needed by them irrespective of the actual feeding value of the material, and which may or may not be supplemented by more nourishing feeds. In the dry season when little or no grazing or green feed is to be had, straws become the most important and, for many classes of stock, the only kind of fodder available ; even in the rainy season and when green feed is abundant cattle have to be given and indeed appreciate an addition by way of some dry straw. The chief merit and almost the only purpose served by straws is the provision of the large bulk which is required to fill the very extensive digestive tract of cows and buffaloes and to help in making these organs function normally. This bulk is very necessary, and has to be satisfied even though we may give the animal all the nourishment it may require in the shape of concentrated feeds of various kinds.

Among the general characteristics of straws as fodder apart from their bulk may be mentioned (1) their low content of nutrients and (2) their coarseness.

We have already explained that crops build up food material in the shape of their green leaves and stems and continue to do so during what may be called the first phase of their development. When they begin to bear flowers, the second phase may be said to begin, during which comparatively less new material is built up. When they begin to mature their grain or seed the third phase begins and during this period, there is only a transference into the seed of the materials stored up in the leaves and stems and little or no new material is built up. The green chlorophyll is all changed and withdrawn and the leaves lose their green colour. As the grain matures

more and more of the nutrients are drawn into them and the leaves and stem become proportionately depleted of the nutrients in them, and by the time the crop is fit for harvest these portions which form the straw are comparatively of little value as regards their content of nutrients. The seeds or grains are utilised as human food or as concentrated feed for cattle. The grain is the main product for the sake of which the crop is cultivated and the straw is only a bye-product, which fortunately is eaten by cattle and therefore finds a profitable use and serves an all-important purpose at the same time. It is not in every part of the world that the straw is put to this use ; in the large-scale prairie farming in the U.S.A., and similar countries the immense quantities of straw that are obtained are left either to rot on the ground or burnt to prevent them from cumbering the ground. Things are however changing and at present a fair proportion of the straw is baled and brought to the barns for the use of cattle. At the other extreme, are countries like Japan and China, where the straw is turned to industrial use, for making straw hats, baskets, shoes and so on and the few cattle which are kept have to compete for their share of even this poor fodder, with these industries. In India the straws are the mainstay of cattle ; every bit is carefully saved and stored, and later doled out ; even of this fodder cattle get enough or not, according as they are working or milk cattle or merely dry animals from which the farmer gets no return, unless it be some manure. There is seldom enough to satisfy all the animals on the farm, and often there is not enough even for the better class of animals. Bad seasons and scarcity are of frequent occurrence when great distress prevails, and cattle die for want of even this fodder. The importance of straws is thus obvious, though it may be called coarse, innutrious, dry and howsoever in addition we may choose to decry it.

The second general characteristic of straws is their coarseness. We have explained how it comes about that straws are very poor in nutrients. Their coarseness arises from the fact that a good portion of the leaves and stems become hard and woody as the crop matures. This

is apparently a provision of nature for making these parts strong enough to sustain their erect growth and bear the weight of the earheads of grain. Anyhow at the harvesting stage much of what is called straw consists of these hard woody stems, the somewhat softer portions made up of the leaves being more or less according to the kind of crop. The straw of a crop like juar consists of such stiff and hard stems that they are often fit enough to be tied into hurdles, screen walls for enclosures and so on. So likewise is the straw of the *'sajje'* or *bajra* crop. The straw of certain millets like *'save'* or *baragu* on the other hand is so soft that at one time it was largely used for stuffing pack saddles and mattresses. This coarseness takes away much from their value as fodder small as it is. A good portion of such very coarse fodders is left untouched by cattle and has only to be thrown away on the manure heap or used as fuel. Any one who is acquainted with the juar tracts will have seen the large quantities of juar stems left over and wasted and which have to be cleared every morning from the mangers. Even in consuming and assimilating such portions of this fodder as the animals do actually eat, they have to expend a very large amount of energy, often quite disproportionate to the food value which they may derive from such fodder. We shall go into this matter in some detail presently. Of course not all straws are alike in this respect; as mentioned already, the juar and *'sajje'* represent the coarsest types while the *'save'* and *baragu'* represent the other extreme, and between these are the straws of rice, ragi, wheat, etc., which may be said to be intermediate. Even in one and the same kind of crop the coarseness of the straw may differ according to circumstances ; thus the straw of irrigated ragi is much coarser than the straw of dryland ragi, so much so indeed that it is seldom cut and stacked for fodder like other straws. Similarly the straws of different varieties of the same crop such as rice for instance also differ in their fodder value. Further in the case of ragi, the straw obtained by threshing the grain under the feet of cattle is softer and is relished better than the straw obtained by threshing under the stone threshing roller.

This coarseness and the low content of nutrients in straws, which form their general characteristic account for the fact that animals have often to spend more energy in feeding on them than the energy which they can obtain as the result of such feeding. The energy supplied by the different foods can be obtained by the animal only by the expenditure of some energy on its part, which is required for the purpose of reducing by means of its teeth, mouth, the different stomachs and the digestive tract generally, into a condition fit for assimilation. If the energy so expended is very much less than the energy derived from the fodder then the animal benefits by the food ; if it is almost equal to the energy derived from the fodder then the animal derives little or no benefit from the fodder ; and if the energy expended should be greater than the energy derived, then the animal positively loses energy and if the same fodder should be continued by itself then the animal will continue to lose energy and become weaker day by day, in spite of the fact that she is eating all the time and we may think that she is being properly fed. This is what happens in the case of most animals during the hot weather months when they get no green grass nor any grain feed but only dry coarse straw. Under such conditions animals can undergo only a slow process of emaciation, which may continue and end their life if it were not that the rainy season sets in meanwhile and green grass becomes available to some extent.

Although animals thus derive little or no benefit commensurate with the energy that expend in consuming the straws, still it is possible to reduce this expenditure of energy and thereby to increase in effect the energy derived from the fodder. This is accomplished by subjecting the fodder to various treatments which will have the effect of softening them or making them less coarse and so to make it easier for the animal to get at the nourishment locked up in the fodder, meagre though it may be. Thus the straws may be (1) chaffed or broken into shreds, (2) may be soaked in water, hot or cold, overnight and softened, and (3) treated chemically with dilute caustic alkali, which has the effect of breaking down

the coarse fibrous tissue, and of changing the composition of some of the nutrient materials so as to make them easily assimilable. The change brought about by treatments (1) and (2) are purely physical, and the saving in work or energy on the part of the animal is not great, although it is material. The more fine the chaffing or shredding in the first case, the greater is the saving in energy to the animal. Likewise the greater the softening effected, the greater the economy. For this purpose it is usual in the case especially of juar stalks to run water into the feeding trough or mangers which are constructed watertight and put the stalks cut into small bits in this water to soak overnight. In parts of the *malnads* it is usual to chaff rice straw and soak it in boiling water for some hours and then feed it. In spite of all this, a lot of all these fodders is wasted, but the treatment certainly effects considerable mitigation. The chemical treatment, *viz.*, (3) is certainly the most effective in this respect. It consists in boiling the shredded straw in a solution of weak soda lye, *i.e.*, having a strength of 1¼ per cent. for about 24 hours, draining off the spent lye, and then washing the treated straw with water until it is quite free from alkali. The method is of course expensive and even if the price of soda should come down very much, it is doubtful if it can be taken up by the ordinary agriculturist. There is the question of suitable containers of sufficient size, the supply of abundant water, and the knowledge required to carry out the work carefully, all to be considered. We may however mention that the process is said to practically double the feeding value of the fodder.

The method is specially recommended for treating rice straw (see page 63). An alternative method which solves the difficulty of obtaining caustic soda at a cheap price and in many tracts of obtaining it all, is to use ordinary quicklime as a substitute. This is a familiar article and is easily available everywhere and is also very much cheaper than caustic soda. For this treatment 100 lb. of chopped straw is soaked in a vat of 100 gallons capacity containing a well-mixed solution of 80 gallons of water and 12 lbs of quicklime, and is kept sub-

merged in the solution for 12 hours. The liquor is then run off and the straw thoroughly washed in water to free it completely from the lime solution. (N. C. Das Gupta.)

Another circumstance which somewhat mitigates this particular characteristic of straws is the fact that Indian cattle are able to digest more of these fodders than European animals and are thus able to derive more benefit from them. This peculiarity of the digestive system of Indian cattle thus appears to be a fortunate and merciful provision of nature against what would otherwise be a menace to the survival of a large number. The finding is also important and interesting as it amounts to a caution against taking European results as applicable to India in every respect.

We shall now take up the composition and characters of the straws of the different crops.

V

CHEMICAL COMPOSITION OF THE STRAWS

THE observations made so far with regard to the characteristics of the different straws as cattle feeds are based upon their chemical composition and upon actual feeding experiments, as far as possible. We may now supplement them by figures giving the actual percentages of the different constituents, as determined by chemical analysis. We should explain however that the composition of straw is very variable ; not only do the straws of different grains differ from each other but even straws of one and the same grain will differ in composition according to circumstances. This is a feature which marks them off from the grains themselves, which are almost definite in composition, or are certainly very much less variable than straws. This is especially so in the case of the mineral matter or ash content. The composition of straws will vary according to the soil on which the crop is grown, and also according as at is grown as an irrigated crop or a dry crop or a semi-dry crop. The figures which we give below should therefore be taken to indicate only in a general way the composition of average samples. In order to make the figures more informative we give also side by side the composition of green grass, hay and a grain. In forming a comparative estimate of the feeding value of the straw it should be further remembered that the digestibility of the carbohydrates, proteins and fibre is very much lower than that of the same constituents in the grain or even the grass and hay. Such digestibility may go down to 50 per cent. or even 60 per cent. of digestibility of the grain.

The following table gives the composition of these materials ; they are all calculated on a dry matter basis, that is to say, on the weight of the material deprived of all moisture. The wide limits within which the constituents vary, the high content of the mineral ingredients, of the crude fibre and the correspondingly lower content of the carbohydrates as compared with the grain are all points to which attention has already been drawn.

	Proteins	Carbo-hydrates	Fats	Crude fibre	Ash	
					Total	Sol
Rice straw	2·4 to 5·7	42 to 49	0·8 to 1·5	30 to 35	13 to 20	·2
Ragi ,,	2·2 to 3·8	45 to 56	0·6 to 0·8	33 to 35	6 to 8	5
Jola ,,	2·5 to 5	50	1·2 to 2·5	35	10 to 12	5
Wheat ,;	3·2	42 to 45	1·5	39 to 42	11 to 12	4
Hariali hay	11·0	46	2·0	25	15	6
,, grass	13	43	2·0	31	11·7	6
Wheat grain	9·7	85	1·2	2·4	1·9	1

—*Taken from Misc. Bulletin No. 25 of the I.C.A.R.*

by K. C. Sen.

One point however (there are probably others) which the analyses do not bring out is in regard to what the cause may be for popular preferences to one or other among them. For instance, the general belief in Mysore is that rice straw is poor and can on no account take the place of ragi straw. During the great fodder famine which prevailed in the years 1924 to 1926, when rice straw from the channel areas of the Mysore District was the only straw that was available and which was brought in large quantities and taken to Bangalore, Kolar and other districts for relieving the distress, it became very difficult to sell this straw, as the ryots would not agree to purchasing it, saying that rice straw was injurious to their animals. Curiously enough the exact contrary difficulty was experienced by Dr. Buchanan when he toured Mysore with his convoy of bullock carts and pack bullocks, all of which came from Madras; the cartmen are reported to have stoutly refused to feed their animals on ragi straw, saying that ragi was not as good as rice straw and that it would prove injurious to their animals! Much of the belief may be the result of the nature of the tract from which the animals come and the straw to which they may be accustomed, such as rice straw in the rice-growing tracts or ragi-straw in a predominantly ragi-growing tract.

It will be interesting in this connection to note that the composition of rice straw is such that there is good founda-

tion for this belief in its great inferiority as a fodder. It has been found that persistent feeding with rice straw interferes with the taking up of calcium by the animal's system and that there ensues in fact a depletion of the store of calcium in the body with persistent feeding of rice straw alone. This deleterious effect is found to be due to the presence in the rice straw of the salts potassium and calcium oxalates ; the calcium in its combination with oxalic acid is not assimilable and therefore is not absorbed and simply passes out of the system; the potassium oxalates decompose in the fore stomach of the animal producing alkalosis, which reduces the solubility of calcium in the feeds and thereby prevents its absorption. The combined effect is therefore an almost complete deprival of calcium to the animal and a serious calcium deficit.

It must also be stated that the finding does not apply to the straw of all varieties of rice and some varieties are free from this defect. (The work referred to above relates to *Aman* varieties in Bengal .) This seems to show that neither the Madras nor the Mysore cartmen in the caravan were to blame, their experience evidently related to the straw of different varieties of rice !

Reference has already been made to the treatment of such straw with dilute caustic soda and subsequent washing (see page 59). The effect of this treatment is twofold. Firstly if removed the deleterious effect of potassium oxalate and improved the assimilation of calcium. Secondly it increased the digestibility of the carbohydrates, of which much of the coarse portion of the straw was composed and therefore the nutritive value of the straw as a whole was improved. As far as the first effect is concerned, it is obvious that plain water itself should be able to dissolve out the potassium oxalate; as a matter of fact this has been found to be the case and that mere soaking and washing in water will remove a considerable portion of the potassium oxalate and will increase calcium assimilation. As far as the second effect is concerned the finding is capable of being applied to other coarse fodders also although it has not formed the subject of special trials.

We may summarise the qualities of straws as feeding stuffs, by stating firstly that they are very poor in nutritive value, secondly, that they serve nevertheless a very important function by furnishing the bulk necessary in the feed, that by themselves they can keep animals only at or even below maintenance level, that it is possible by mechanical and chemical treatment to make them more nutritious and lastly that many of them contribute materially to the mineral requirements of animals.

We may close this section with a few remarks about what is called, "chaff". This term is applied to the portion of the plant material, which is composed of the glumes, husks, bits of the panicles, and of straw itself together with more or less of the grain or other pulses, which have only imperfectly developed or not formed any seed at all and which are therefore very light and are separated out in the winnowing process. Chaff is also mixed up with a lot of foreign matter like bits of weeds, broken stems of the crop itself and considerable earth, gravel, etc., from the threshing floor. Made up as they are of this odd assortment of materials, their value as a fodder is very variable; for one thing they are in a finely divided condition and do not entail the same amount of work as straw does for mastication. If the fraction made up of the immature or imperfectly developed grains or pulses is high, then their fodder value will be proportionately more. Much, if not all, of both these advantages may be largely neutralised if the chaff is not properly cleaned. If the fraction made up of bits of woody stems and coarse husks, etc., is high then it may become both useless and even positively harmful. On the whole, it will pay to collect the chaff in such a manner that it will be composed entirely of the better class fraction.

The portions of the grains or pulses which are composed of the skins or seed coat, or of the outer layer of the naked seed itself (after the skin has been removed) come in a different class. Except (in the case of the paddy) in which the outer husk is coarse and perfectly useless as fodder, in the case of the others this forms an important cattle feed, being known as bhusa, or *hottu*. In the case of rice itself, the outer layer of the husked

grain is removed to a greater or less extent in the milling and polishing process, and this product under the name of bran or *thavidu* is also an important feeding stuff. All these come in a class by themselves and we shall deal with them in a separate section. These are not to be confused with the 'chaff' we have described above.

VI

CONCENTRATED FEEDS

THE cattle feeds called concentrates or concentrated feeds differ from the bulky feeds considered so far, in that they contain within a small bulk or quantity a comparatively large quantity of the nutrient constituents, such as proteids, fats and carbohydrates. They are so to speak a kind of "much in little", in this respect. They are also referred to sometimes as "purchased feeds" in contrast with the fodders which the farmer raises in his farm, such as straw, green fodder, etc. These concentrated feeds comprise, firstly, the brans of the various cereal grains, refuse or rejected fractions of the grains, themselves such as broken grains immature or under-sized grains, and the coarser portions generally, occasionally the grains themselves, and spent grains like what is called "brewers grains"; secondly, the various pulses, both entire and more generally in the shape of only the outer skins, and broken bits; and thirdly the edible oilseeds and their oilcakes, which form the material left over after the oil is expressed.

Rice Bran.—The commonest among the concentrated feeds may be said to be the brans of rice and of wheat in the tracts respectively where the staple food crop is rice or wheat. The bran proper consists of the outer or cortical layer of the grain after the husk is removed; very often, however, there is a mixture with small quantities of little bits of the husk itself, which persists even after cleaning. This admixture or impurity is harmful, especially in the case of rice, as the husk is very coarse, almost gritty, being composed of a large percentage of silica in its ash content. The outermost layer of the rice grain (husked grain) contains most of the proteids, the oil or fats and the mineral components. As the interior is reached these constituents become less and the content of pure starch increases. When the paddy grain is husked, a certain portion of the bran or outer layer, which is really the outermost portion, is removed also, as it adheres to the grain very loosely and some of the

bran is therefore lost with the husk. This is unavoidable. Further pounding or polishing of the rice removes more and more of the pure bran, and if the polishing is thorough then the bran is completely removed. This however, is not the case in all kinds of rice. The red-colour of the rice (and difference in composition which it implies) persists as a very firmly adherely coat in some rices, and in others even extends deep into the grain. The red colour becomes lighter as the centre is reached which consists of a core of almost white or colourless starchy material. With this latter type of rice at one extreme and the type in which the bran is so easily detached that the rice requires comparatively little polishing, at the other there are many grades, which require varying degrees of polishing to free them from bran.

The desire to polish the rice and to deprive it of its bran is due to two causes. Firstly, the bran is not so easily digestible as the whiter portions of the rice and is therefore not suitable to weak stomachs and even to ordinary stomachs in many cases. The rices with a firm bran coat which are somewhat difficult to clean, are generally the coarser rices and are red in colour. Secondly, people like to have the cooked rice which they eat, white like a heap of "jasmine flowers", as the saying goes, and not red or reddish like a heap of "tamarind flowers". The latter is a mark of distinct lower status in society on the part of the consumer. The desire for polished rice may go to an absurd extreme, as it does in Europe and America, where the popular demand is for a brilliantly white rice; the trade meets this demand by the use of special polishing materials like talcum powder, oils and waxes, etc., which turn out rice resembling shining white pearls. To prevent this practice from causing injury to the consumers of rice the 'pure food' laws step in and regulate the polishing and penalise the use of excessive polishing material! There are however exceptions to this general desire for white or polished rice which also present interesting features, in regard to the abuses in the trade. Most of the red rices, *i.e.*, those in which the bran adheres very firmly, are distinctly more palatable, and in certain tracts there is a special prefer-

ence to this rice and a higher price is paid for it than for the ordinary kinds. This higher price has opened the door to fraud, by the petty trader who in these tracts colours the rice artificially by rubbing it up with red earth among other things, and passes it off as real genuine red rice: The fraud is of course detected when the rice is washed prior to being cooked! Another exception where colour in cooked rice is tolerated or perhaps desired is in households where the rice grain is mixed with the powder of turmeric during storage, in order to keep off the rice weevil; such rice when cooked gives a yellow coloured cooked rice, even though much of the turmeric powder and colour is removed when washing the rice preparatory to cooking. On the whole however the preference is for white rice deprived of all the bran as far as possible.

The bran so removed is excellent cattle feed and is carefully husbanded and used for this purpose. The quantities available are quite considerable; a palla of 100 Mysore seers of paddy will under ordinary husking or milling methods yield some 6 to 8 seers of bran fit for cattle feed. The total quantities that will be available in the country can easily be realised. Bran is thus a very important source of concentrated feeds for cattle in the country and under ordinary village economy where each household husks its own paddy or arranges for husking it in the same village, cattle should have been pretty well supplied in this respect. With large power milling establishments working in the towns or the larger centres of production or at the railheads, and the consequent drawing off of all the paddy from the smaller centres, supplies of bran become less readily avaiilable to village cattle. Moreover during recent years, the value of bran as a human food and the harm to human health resulting from eating rice divested of all the bran have been the subject of much propaganda and as a war measure the polishing of rice beyond a limit was also been forbidden and the ban still continues on account of the serious food shortage in the country. These developments have led to a further curtailment of the supplies of bran available to cattle. But despite these

conditions and the competition as a human food, rice bran will remain a very important and a very dependable source of cattle feed, though supplies may not be so very abundant as under the old conditions.

As compared wth rice in composition, the bran is very rich in the fat or oil content, in proteids and in minerals. Thus the composition of bran and of rice are shown below:

	Crude proteins	Fat	Carbo-hydrates	Ash
Rice ..	8·3	0·8	89	1·2
Rice bran ..	10 to 15	13 to 20	36 to 40	15 to 20

The most noteworthy difference is in respect of the oil or fat content. While this is a great advantage, it necessitates also an important caution. The oil in the bran is likely to undergo oxidation and become rancid, if the bran is stored for any length of time exposed to air. The product then becomes both unpalatable and injurious to the health of the animals and hence much less fit as a feed. Bran has therefore to be as fresh as possible, for being used as a cattle feed.

Brans may differ in quality according to the method of husking or milling adopted. We have already mentioned the likelihood of a considerable quantity of finely powdered husk being included, when rice is milled in the power mills. Brans greatly improve in quality if the germ or embryo of the rice is also included in it, as it is so included in certain forms of husking. Thus, where the pestle and mortar are used or the same form adapted for the so-called "yeta" or "picota" style of working, then the germs are removed along with the bran layer, to a very much greater extent than when the grain is husked in the wooden paddy husking domestic mill. The germ or embryo in the rice is so situated outside the rice grain and adheres so very loosely to the grain, that it can be easily detached, in the process of husking. The husking with the wooden domestic mill does not pound the paddy grain so much as the pestle and mortar arrangement and therefore leaves a large percentage of the

germs intact and s'll adhering to the grain. The rice obtained by such husking is richer but the bran is poorer. In fact in all forms of milling, the bran gains in quality as the rice goes down in quality and *vice versa.*

Apart from the chemical composition, one of the outstanding merits of rice bran is its content of *vitamin B,* the so-called antineuritic or anti-*beri beri* vitamin. Rice bran possesses the distinction of being one of the first if not the very first article of diet, concerned in the classic discovery of the existence and value of these vitamins or accessory food elements. The *beri beri* disease in humans and the muscular lesions produced by the disease "pellagra" in birds, were found to be amenable to treatment and cure by the inclusion of rice bran in the food. The large and growing research on the subject of vitamins, may be said to have had its starting point in this special character of rice bran. The need for including some of the bran layer in the rice itself is based upon the presence of this vitamin in the bran quite as much as upon its content of the usual food elements.

Wheat Bran.—Wheat bran is a similar bye-product from the milling of wheat. The milling of wheat is however a more complicated process, in the course of which the wheat grain is separated into many different grades of flour, almost layer by layer, so that each fraction retains its distinctive composition and colour, which vary as is well known from the cortex or skin of the wheat down into the soft white mealy core which yields the almost pure white wheat starch called 'maida' flour. The result is that bye-products of different kinds can be got, which go by the names of bran, pollards, grit and so on. The coarsest and cheapest is the bran and this is what is largely and exclusively used as a cattle feed. Compared with rice bran it is a more nutritive food, contains more proteins and carbohydrates but very much less oil or fats. Its content of fibre is also less, which makes it less wasteful.

The following is the composition of ordinary wheat bran (on a moisture-free basis):—

Proteins: 12 to 15, Carbohydrates: 60 to 65, Fats: 1·7 to 3·5.

Wheat bran is also much more costly than rice bran.

In addition to the bye-products like those described above, the cereal *grains* themselves are sometimes given as cattle feed, either the broken bits and poor grades of the grains, or the sound grains themselves. Such feeds are of course very nutritive and more easily digestible, but are much too costly to be thought of as cattle feed. In predominantly rice growing tracts like the malnads and Malabar rice itself is fed to a small extent to animals in milk. Elsewhere, they are fed to a certain extent, generally to sick or convalescent animals. The grains are then fed more in the shape of a gruel prepared from the flour.

Brewer's Grains.—A bye-product of some importance obtained from the grain barley, is what goes by the name of "brewer's grains" and "malt coombs" In the manufacture of beer from barley, the grain is first soaked in water for a long time and then allowed to sprout; in the sprouting process the starch of the grain undergoes a chemical change and is converted into soluble sugars. The growth of the sprouts is then arrested or killed by heat, and the sprouts are rubbed off and removed ; in this condition they become available as a cattle feed under the name of "malt coombs". The barley grains themselves are then soaked in water and the sugary matter dissolved off to be used for fermenting into beer. The "spent" grains after being thus deprived of the sugar become available as a cattle feed under the name of "brewer's grains". It is a sloppy wet mass containing some 75 per cent. of water, has a pleasant sugary smell and is greatly liked by cattle. In the fresh state it may contain 10 to 12 per cent. of carbohydrates and some 5 or 6 per cent. of proteids. It is also dried to a moisture content of about 10 per cent. and put out as "desiccated brewer's grains". This is of course a concentrated product as compared with the moist grains. The "malt coombs" are a more nutritive product than the grains. Both these bye-products become available in the neighbourhoods of large breweries, where they are readily bought by dairymen.

The Pulses and Their Bye-Products

The next important series of concentrated feeds are furnished by the various pulses, which are used both by themselves and in the shape of their bye-products such as the skins or seedcoat and broken bits. India produces a large variety of pulses, such as tuver (*Cajanus indicus*) . avare (*Dolichos lablab*), kadale or Bengalgram (*Cicer arietinum*), black gram or uddu (*Phaseolus mungo*), green gram or hesaru (*Phaseolus radiatus*), cowpeas or alasandi (*Vigna catiang*), horse gram or huruli (*Dolichos biflorus*), lentils or masur (*Lens esculenta*). All these are grown on a very large scale and the production is as important as that of the grain crops themselves. They form an important and indispensable adjunct to the grains in the dietary of the people and furnish the all-important proteid portion of the diet. All these have to be husked and prepared into the form called *dhal* or split pulse before they can be used in cookery, although to some extent they are consumed entire also, either boiled or fried. In the process of preparing the split pulse the skins which are the coarser portions of the pulse are removed and, depending upon the condition of the pulse and on the skill of the person, more or less of breakage takes place and the broken bits form a smaller or larger proportion. The skins and the broken bits are separated from the split pulse and are used exclusively as feed for cattle while the spilt pulse itself is used exclusively as a human food. Although this is the practice with nearly all the different pulses, still some of them are used in their entirety as cattle feed very largely, while others are used as such to a smaller extent. The pulse called horse gram is raised principally for being used as a cattle feed, while the pulse called Bengal gram is also largely used as food for cattle and horses. The other pulses are used in the same way to a small extent. The seeds of the leguminous fodder or vegetable crop guar (cluster bean) are rather exceptional, as they are used solely as a cattle feed.

The pulses differ from the grains particularly in the much larger percentage of proteids in their composition.

Thus while the proteids in the grains may range from 8% to 12% only, the percentage in pulses will range from 18% to 25%, and in a pulse like the soya bean may go up to even 40%. They are essentially proteid foods, as distinguished from the grains which are essentially starchy or carbohydrate foods. The proteids have to form an indispensable part of the food, and their proportion in the food will have to be varied according to the condition of the animal. Calves and growing animals have to be supplied with a larger proportion, so likewise are animals in milk, than fully grown animals or dry cows and buffaloes. The proteids are more costly than the starches or carbohydrates, being reckoned at about three or three and a half times the latter, though market prices may often upset this ratio. As between themselves the different pulses differ in the percentage of proteids they contain. For example, the proteid percentages in the above-mentioned pulses are roughly as below:—

Tuver 22 to 25 ; avare 25 ; kadale 17 ; black gram 23 to 25 ; green gram 24 ; cowpeas 24 to 25 ; horse gram 22 ; lentils 25.

Although these figures form a guide to the comparative values of the different pulses and of the extent to which one can replace the other in the rations, still there seem to be factors other than the chemical composition (as at present known) which affect their comparative values, and which in ordinary practice appear to be even more important.

As is well known each of these pulses is credited with some characteristic quality either as its special merit or demerit, as distinguished from others in their feeding value. Thus, the pulse green gram is often thought the safest and least harmful, the pulse Bengalgram and horsegram to be difficult of digestion and to lead to flatulence, the pulse *tuver* to be very nourishing and tending to promote growth and fattening. The pulse blackgram is quite distinct in that it yields a somewhat sticky and mucilaginous mass when ground up with water, unlike other pulses; it also holds high place as a proteid food,

being in fact considered equal to animal food, and indeed considered as having been popularised by the Buddhist monks as a substitute for meat. Black gram is also credited with the property of increasing the production of milk, and the same quality is also attributed to cowpeas. There may be other special qualities and other beliefs regarding their qualities held in different parts of the country. We mention these to show that in the ration or dietary of the animal, one pulse cannot take the place of the other and act as a perfect substitute, even though they may be fed in quantities which will supply exactly the same quantities of proteids. Science has not yet sufficiently elucidated this feature, which must presumably be due to differences in the nature of the proteids themselves.

Much advance has certainly been made in our knowledge of proteids; all foods containing the same percentage of nitrogen (the special element which distinguishes the proteids) were at one time considered alike and it marked a great advance when the proteids of the animal kingdom were found to have a different composition from the proteids of the vegetable kingdom although both contained the same quantity of nitrogen. Further work has also shown that proteids of the same composition differ a great deal in what may be called their "make up", and that as far as the benefit to assimilation by the animal system is concerned, the best or most suitable are those whose internal "make-up" is closely similar to, if not identical with, that of the tissue that it is meant to build up or nourish. This aspect of the matter leads to very interesting speculations but it is needless to enter into them here. Suffice it to say that there are proteids and proteids, and few can act as perfect substitutes, among one another. That the pulses are not of equal value in nutrition although even when they may be supplied so as to furnish the same quantity of proteins in the food is brought out strikingly in the following feeding experiment, in which raw milled rice was fed in conjunction with each of the different pulses tuver, soya beans, Bengal gram, black gram and green gram:—

Source of protein		Average increase in growth rate
Raw milled rice plus	tuver	7·4
do.	soyabean	6·5
do.	Bengalgram	6·8
do.	black gram	5·5
do.	green gram	7·5

(R. Swaminathan, in *Ind. Jour. Med. Res.*, 1937, Vol. 24 & 25.)

We may also refer, without going into details, to a summary of the present state of knowledge regarding the comparative values of the different pulses, based upon all the relevant factors which influence them such as "biological value, digestibility, total protein content, net protein value and the percentage of cystine, tyrosine, tryptophane, and histidine." On this basis the various pulses ran as below:—

I. Bengalgram and black gram.
II. Green gram, Lentils, Cowpeas, Soya beans.
III. Field peas, Field beans and khesari.

(Summary by R. K. Pal, in *Ind. Jour. Agri. Res.*, Vol. 9, Part 1.)

The practical bearing of these observations lies in the fact that in any particular ration it is advisable to furnish the required quantity of proteids in the shape of a mixed lot of two or more pulses, rather than in the shape of any one of them. This is what is being done as a matter of fact in many households, where the feed for milking animals is made up of a mash in which a small handful of the different pulses such as black gram, cowpeas, and Bengal gram is ground with other ingredients of the feed.

Proteids also differ in the proportion of the digestible part in them, some contain more, some contain less. The range of variation may lie between 90 roughly as the maximum down to 30 per cent. or even less. As in the case of other feeding stuffs the digestibility can be helped or increased by preparing the feed suitably, by boiling, grinding, soaking in water and so forth, instead of feeding them raw and entire. Seeds with a hard seed coat, like horsegram for instance, will often pass out

quite intact along with the solid excreta even though the animal may have expended considerable energy in trying to break it up by mastication in its mouth. It will greatly help therefore if the animals are spared this energy, by means of the above-mentioned methods of preparation.

The bye-products of the pulses.—As already explained it is the bye-products obtained in the process of converting the pulses into their respective 'dhals' (or split pulses) that are used as cattle feeds exclusively and very much more largely than the pulses themselves. As compared with the pulses they are all coarser feeds, contain less nutrients, and also vary much in their nutrient constituents according to the proportion of the bits of the 'dhal' contained in them. It is the proportion of the latter in any particular kind of feeding husks that decides its price. The greater the proportion of this fraction, the higher the price and *vice versa.* The feeding husks usually available in the market are those of *'Tuver'*, Bengalgram, and Avare (*Dolichos lablab*). It is difficult to say if there is any difference in the feeding values of these husks, other than what may be due to the proportion of the bits of dhal in them; but popular opinion in Bangalore at least puts them in the order given above. As between the first two, the preference is not always the same, sometimes Bengalgram husks are considered better and sometimes *'tuver'* husks, but the *'avare'* husks rank invariably last. Their composition is very variable for the reasons already stated ; roughly the proteids may vary from 5 to 8, the carbohydrates from 38 to 45, and the crude fibre from 45 to 50, and the ash content from 6 to 9 per cent. In view of the high content of the fibre in all of them the desirability of softening them by soaking in water applies to these feeds to an even larger degree than to the pulses themselves.

Coarse and innutritive as they may appear in comparison with other concentrated feeds, it is a surprising fact which may not be generally known that their protein value is very high. In feeding experiments with dairy animals (Hissar heifers) conducted to determine the comparative values of some of the concentrated feeds in

India, *viz.*, groundnut oilcake both decorticated and undecorticated, linseed oilcake, rape oilcake, til oilcake, guar (clusterbean seed), Bengalgram, arhar chuni (tuver husk), mung chuni (green gram husk), all of which were given in quantities necessary to maintain the same level of protein in all the different treatments, it was found that their effect as measured by the growth increase not only differed very much as between one and another but that the best effect was produced by the husks of tuver and green gram. The results are symbolically represented as follows:—

Groundnut cake (undecorticated)	..	..	4·58
Groundnut cake (decorticated)	..	..	4·96
Til cake	..	..	5·15
Rape cake	..	..	6·30
Linseed cake (average of three)	..	..	6·94
Guar (clusterbean)	..	..	8·03
Bengalgram	..	..	8·77
Arhar chuni (tuver husk)	..	..	8·79
Mung chuni (green gram husk)	..	..	8·83

(N. C. Das Gupta, *Ind. Vet. Jour.*, Vol. **24**, No. 1)

VII

THE OILSEEDS AND OILCAKES

THE oilseeds which furnish edible oils and their oilcakes constitute the next class of concentrated feeds. They may be regarded as the most important among such feeds forming as they do an indispensable part of the daily rations of dairy animals throughout the world. They form the foundation on which the flourishing animal husbandry, comprising both milk and meat production, of the most advanced countries of Europe and America rests and enormous quantities are imported annually into these countries from centres of production in the tropics. In fact the production of meat and milk flourishes or dwindles in proportion to the quantities imported. They form a costly item in the ration and therefore considerable knowledge and experience are needed in order to obtain the maximum benefit from their use.

The various oilseeds which furnish edible oils are the following:—gingelly, til or sesamum, groundnut, linseed rape or mustard, coconut, palmnut, cotton, niger and safflower ; the famous soya bean which is strictly not an oilseed may also be included in the list on account of its very high oil content, in contrast with the pulses with which it is usually classed. The oilseeds are not generally fed as such, but are fed only in the form of their oilcakes, that is to say, after the oil has been extracted from them. The oilcakes really form therefore the bye-product of the oil crushing industry and are made use of as cattle feed, while the main product is the oil itself which is used as a human food or for industrial purposes. All oilseeds are rich in oil and in proteids as distinguished from the grains and pulses considered so far. Of these the grains supply mainly the carbohydrates, and the pulses supply proteids as well. The oils and the carbohydrates serve the same kind of purpose in the animal system, *viz.*, to supply the energy required whether for maintenance or work or production. The fats

are much superior in this respect, and much more valuable. They can supply about $2\frac{1}{4}$ times as much energy as the same weight of carbohydrates and can therefore replace the latter in that proportion. In the crushing of the oilseed for removing the oil, the seeds are not completely deprived of the oil. Depending upon the method of oil extraction employed more or less oil is left in the oilcake unexpressed. In the ordinary country *ghanas*, driven by bullocks, the pressure is not great and considerable oil is left in the cake; even among these *ghanas* the wooden mills will extract less than the stone mills. In the iron rotary mills, the efficiency is greater and somewhat less oil is left in the cake ; a more efficient type is the hydraulic press and a still more efficient one is the so-called Expeller. No amount of pressure will however deplete the cake completely of the oil. Such thorough extraction can however be effected and this is done by treating the meal or the cake with chemical solvents. Such treatment leaves the exhausted material in the shape of a dry powder in which the smell of the solvent generally persists and renders the powder unsuitable as a cattle feed. From the point of view of utilisation for feeding, the cakes are all obtained only by pressure, or by pressure combined with heating for breaking the oil cells. These cakes differ not only in their oil content according to the method employed for extraction but they differ in their mechanical condition also. The cakes from the country mills are in the form of large and very thick hard lumps, while the hydraulic press cakes are in the form of rectangular slabs very much thinner and easier to break. The Expeller cakes are in the shape of thin flakes which can be crushed even more easily. Considerable adulteration may be practised in the crushing process and more or less of the husks of the oilseeds may be included, which will affect not only the content of nutrients in the cake but also its digestibility on account of the coarseness of the husks. The liability to adulteration is greater in cake sold in the milled or powdered condition. Where large quantities are purchased it will be necessary not only to purchase it on the basis of a chemical analysis or

guarantee of composition but also to protect oneself against adulteration by a proper examination of the material.

The difference in the composition of the grains, pulses, oilseeds and oilcakes will be made clear from the following statement of their main ingredients:—

	Rice	Tuver	Gingelly	Gingelly Oilcake
Carbohydrates ..	79	61	15	30
Fats ..	1	1·5	49	8 to 12
Proteids ..	6·5	17·5	19	30

Although the oil in the cake is a very valuable constituent, the chief and the more important constituent in the oilcakes is the proteid and it is as a supplier of proteids that oilcakes are made use of and valued in the ration. These proteids may vary from 20 to 50 per cent. in the different oilcakes, depending upon the kind of oilseed they are derived from and also upon the method of oil-extraction employed. In one and the same kind of oilcake the higher the oil content, that is to say, the less efficient the oil extraction, the smaller is the proteid content; conversely the lower the oil content the higher is the proteid content. The oilcakes from the better class of mills are therefore much more valuable than the oilcakes from the less efficient mills.

Cottonseed.—As stated already the oilseeds by themselves are seldom used as cattle feeds. An important exception is cottonseed and to a lesser extent, linseed. Cocoanuts are sometimes given as a feed direct but this should be considered exceptional and more or less a luxury feed. In Mysore it is customary to feed breeding bulls with such luxury feeds which may comprise cocoanuts, eggs, butter, etc., in addition to ordinary concentrates like cottonseed, oilcakes and so on. In certain villages the custom prevails that in addition to a covering charge of Re. 1 or so to be paid by the party bringing the cow for service a seer of butter is also to be given for feeding the bull! Linseed is more or less of a sick diet and is prescribed in somewhat special cases. Cottonseed therefore is the only oilseed which is fed as such and which

we may consider in some detail. Cottonseeds are a favourite and universal cattle feed for both dairy and work-animals in all the cotton-growing tracts of India. The seeds cotain from 17 to 20 per cent. of oil, about the same percentage of proteids and from 25 to 30 per cent. of carbohydrates and form therefore a very nutritive feed. The cotton seed contains however considerable coarse material, which comes from the hard seed coat. In fact their content of 'crude fibre' may go up to 25 per cent. in contrast with 2 to 4 per cent. in groundnuts and gingelly seed. This seed coat moreover is covered with a certain amount of fluff or downy material, which adheres to the coat rather firmly and which is not removed in the ginning. This amount of fluff varies with the varieties ; some varieties are quite naked and the seeds have a smooth clean surface, others have a rather pronounced fluffy coat and still others may be said to be intermediate. The commonest feed is furnished by the varieties belonging to the last class. These are the local or indigenous cotton (called "*Sannahatti*" in Mysore) while the fluffy ones are the so-called American cottons, to which belong the *Doddahatti* of Mysore and the *Cambodia* cotton of Madras. The fluff adds to the coarseness of the feed and in addition there is a strong prejudice among ryots against the use of these seeds for cattle feeding. Experiments have shown however that such fears are groundless and that they can be fed quite as safely as the local varieties or non-fluffy varieties.

Nevertheless the prejudice does continue, some villagers believe that this seed will bring on night-blindness, others allege it is too heating and so on. It is not unlikely that most of these beliefs, whether real or imaginary, arise from the fluffy character of the seeds. In its own home, that is, the Southern States of the U.S.A., it must be pointed out that the seeds are generally delinted and the fluff used for felting and other purposes ; the seed which is available for cattle feed there is therefore somewhat akin to the smooth seeds of the *Sannahatti* and other local varieties of our country.

Where cottonseeds are fed to dairy cattle as such it will be advisable to soak them in water, and then grind

them up into a m sh with the other ingredients of the ration, rather than feed them entire and dry. By preparing the feed in this way, the coarse shells are well ground up; they may not then irritate the bowels and may become generally less objectionable.

The proportion of shells to the kernel is high and may amount to quite 25 or 30 per cent. of the weight of the seed.

Where cottonseeds are available easily and in abundance as in the cotton-growing tracts, about 1 or 1½ lb. per day can be fed to cows of average milk yields while double this quantity can be fed to buffaloes in milk. The ration is generally a mixed one and will contain bran, pulses and pulse husks.

Cottonseed Oilcake.—As in the case of other oilseeds the oilcakes are really the cattle feeds proper, the seeds by themselves being too valuable to be used for this purpose. The oil which is by far the more valuable product is removed by extraction and made use of for human consumption and other purposes. Cottonseed cake has come to be used in this country as a cattle feed only within recent years, with the growth of the oil-pressing industry. Very large quantities are now becoming available, as cottonseed oil is now produced in the country, for the manufacture of one important type of vegetable ghee, *viz.*, the one which goes by the trade name of 'cotogem'. Two kinds of oilcake are made, one which is made from decorticated seed and the other from the undecorticated seed. The latter therefore contains a large admixture of the coarse hulls and the former is comparatively free from this material; it is therefore a safer cake and is for the same reason more costly. Cottonseed cake will have the following approximate composition, which may be compared with that of the seed given alongside for comparison:—

	Proteids	Carbohydrates	Fats	Fibre
Cottonseed	19	26	20	25
Oilcake (decoritcated)	41	16	16	9
Oilcake (undecorticated)	23	6	32	21

As a feed to dairy cattle cottonseed cake is reputed to increase the butter yield and also to make the butter firmer in texture. The cake is also regarded as tending to produce costiveness of the bowels in the animals. The undecorticated cake has to be fed with great caution. In the cottonseed the bad effect of the hulls is somewhat neutralised by the oil in the seed, but in the cake the oil is largely removed, and the coarse admixture of the hulls in the undecorticated cake is likely to prove injurious. It will be desirable in fact to enforce decortication in all the mills which crush cottonseed.

Gingelly (Sesamum) or Til Oilcake.—One of the commonest and certainly the most favourite feeding cake for dairy cattle in Mysore is gingelly or sesamum oilcake. It is also probably the oldest among the oilcakes to be used for this purpose and has therefore the sanction of tradition and long usage in its favour. As a feed for animals in milk its effect is very greatly appreciated and in addition to its property of increasing the milk flow it is also considered to have other beneficial effects on the animal system and to be quite free from any objectionable characters such as are sometimes associated with other oilcakes. The cake contains a high percentage of proteids like other cakes and in addition considerable oil left unextracted. As gingelly seeds are largely pressed for oil extraction only in the wooden or iron country *ghanas*, the oil content in the cake is generally high. Its nutritive value and other beneficial effects are however much higher than can be inferred from its chemical composition alone ; as in the case of the pulses and even food grains, chemical composition alone (at any rate as far as is known at present) is unable to account for its valuable and distinctive properties, as judged by experience and popular belief. The cake therefore commands a much higher price than may be considered warranted by its nitrogen content as compared with cakes with even a higher nitrogen content. In the Bangalore bazaar gingelly oilcake with about 6 per cent. nitrogen sells at Rs. 4-8-0 to Rs. 5 a maund, as against groundnut oilcake with about 8 per cent. nitrogen selling at only Rs. 2 to Rs. 2-8-0 a maund. There are evidently other characters besides the content

of nitrogen or oil which affect the value of these cakes and which are not well known nor properly assessed. Gingelly oilcake will have the following approximate composition:—

Proteids	Carbo-hydrates	Fats	Crude-fibre	Ash
46	28	10	5	11

Linseed Cake.—An oilcake somewhat similar to the gingelly cake in its special beneficial effects on the system in addition to its high nutritive value is linseed cake. Linseed by itself is also fed to dairy and other cattle directly, so that as in the case of cottonseed both seeds and the cake are used as feeding stuffs. Linseed as such is fed only in special cases, such as to sick animals or those which have to be put on special diet on account of any weakened condition, impaired digestion and so on. The special feeding value of linseed and linseed cake is due to the presence of mucilaginous material in the seed which on soaking in water swells up into a soft spongy jelly-like mucilage somewhat resembling sago. The mucilage which is present principally in the seed coat will amount to 5 to 8 per cent. The soothing effect of this material in addition to its food value accounts for the special character of this seed and cake. Like gingelly cake therefore linseed cake has a value much higher than what its nitrogen content or oil content will warrant, as compared with other cakes. The composition of the seed and the cake of average quality is as below:—

	Proteids	Carbo-hydrates	Fats	Crude fibre	Ash
Linseed ..	23	24	37-40	5·6	4·8
Linseed cake ..	30	43	6·5	9·5	10·0

Unlike gingelly oilcake linseed cake is usually treated in modern hydraulic presses and the cakes come into the market in the shape of rectangular slabs about an inch in thickness. It is one of the most extensively used feeding cakes in Europe and America, where both dairy cattle and beef cattle are liberally fed on it ; as seed and as cake it forms a most important article in those countries.

Groundnut Oilcake.—A comparatively new feeding stuff but one which is very highly nutritive with a very high proteid content and which is now available in very large quantities is the oilcake from groundnut seeds. Groundnuts are now grown so extensively that besides being exported in huge quantities large quantities are pressed within the country itself, both on a large scale in modern "expeller" machines but also in the country wooden and iron mills or *ghanas* in almost every village of any importance. The oilcake is now more common than even gingelly oilcake. Groundnut oilcake is the richest in proteids among the feeding cakes. Like gingelly and linseed the seed has only a very thin seedcoat and the cake is therefore equally free from coarse husks or fibrous material. Groundnut oilcake of average quality will have the following composition:—

Proteids	Carbo-hydrates	Fats	Crude fibre	Ash
52	27	8	7	5·7

Not only are the proteids highest, as compared with all the other kinds of oilcakes, but a high percentage of these proteids, *viz.*, about 80 per cent. is digestible. The cake is now used practically in all modern dairies, but there is a great deal of disinclination on the part of the ordinary cow-keepers to feed it to any great extent ; among them it may indeed be said not to be popular by any means. An inquiry made among dairymen in Baroda, where cottonseed is the favourite feed for animals, disclosed a generally held belief that groundnut cake reduced the yield of milk and butter, made the butter and ghee greasy, shortened the lactation period and so on. Whether this is due to the comparative novelty of the material or to any demonstrably objectionable quality it cannot be definitely stated. We can only say that although it is being largely fed in many farms and by many private dairymen also we have not heard of any deleterious results on the health of the animals. On the other hand animals thrive on it. Considering its high proteid content it should be regarded as very cheap in comparison with gingelly cake. However, a scheme of research

was undertaken at the instance of the I.C.A.R. to test the correctness or othe wise of the belief in Baroda that groundnut oilcake was deleterious; the results have shown that this oilcake produces no such ill-effect and that the belief is therefore not well-founded.

Niger Oilcake.—Another feeding cake of some importance in Mysore and Bombay is niger oilcake. The seed contains a large proportion of hard seed coat as compared with its oily kernel and the oilcake is therefore very coarse with the admixture of this seed-coat. The proportion of crude fibre in the cake is very high. The seeds are often mixed with gingelly seeds and then crushed, in which case the cake is not so very coarse. Ordinary *ghana*-pressed cake will have the following composition:—

Proteids	Carbohydrates	Fats	Crude fibre
27	20	14	20

An impression prevails among cow-keepers in Bangalore that the cake when fed to cows and buffaloes induces great thirst and makes the animals drink a great quantity of water, which is said to lead to a larger quantity of milk!

Cocoanut Oilcake.—In the great cocoanut tracts of the west coast and South India and even in parts of Mysore cocoanut oilcake is available for being fed to cattle in large quantities. Both *ghana*-pressed and expeller cakes are available and the former are of course somewhat richer in oil and poorer in proteids than the latter. The cake suffers from the drawback that it becomes rancid and unfit for feeding if kept for even short periods and is therefore valueless for feeding purposes except when it is quite fresh. It has a high feeding value, and the proteids too have a high digestible quality. The composition of *ghana* and expeller cakes is as below:—

	Proteids	Carbo-hydrates	Fats	Crude fibre	Ash
Ghana cake	23	42	13	12	8
Expeller ,,	25	45	8	13	8

Safflower Oilcake.—In the black cotton tracts considerable safflower is grown, both for its own sake and

also because when growing along the margins of fields it keeps off stray cattle from the main crop, on account of its spiny leaves. The crop yields an edible oilseed, from which oil is also extracted. The oilcake forms an important cattle feed in these tracts. It is obtained as very hard lumps, mixed with considerable coarse material derived from the hard seed coat. The cake has the reputation of keeping well for long periods, unlike the cakes considered so far. It varies much in its feeding value, because the seeds are crushed either whole or with the husks removed to varying degrees. The greater the quantity of husk in the cake the coarser is the cake and the lower is its feeding value. Ordinary samples may have the following composition :—

Proteids	Carbohydrates	Fats	Crude fibre
38	21	10	20

Rape Oilcake (also, the almost identical cakes called mustard and sarson).—This is a feeding cake which has a large vogue in Upper India but is almost unknown in South India. The cake forms an important cattle feed in Europe also, for which purpose both seed and cake are extensiveiy imported. The cakes are of high feeding value but as the seeds are very small they are often very impure, either because they are not well cleaned or because they are adulterated wilfully; the oilcake is therefore correspondingly impure with admixture of foreign matter, some of which may be deleterious to cattle. The seeds contain a pungent principle, which may irritate the stomach. Seeds and cake are generally steamed so as to destooy this principle and render the cake safe. The composition of ordinary rape cake be as follows:—

Proteids	Carbo-hydrates	Fats	Crude fibre	Ash
36	33	13	8	9

General.—As in the case of the other feeds and fodders it will be necessary to prepare oilcakes for feeding in such a way that cattle may eat the feed with ease and without having to expend any energy in crushing or breaking them down. Oilcake may be purchased either

whole or in the form of a meal or powder. The former is preferable. When thus bought whole, it should be converted into a suitable form, for the consumption of the animal. For this purpose it is broken into small lumps in machines called cake-breakers. On a small scale, it will be enough if the cake is soaked in water for a few hours, when it falls readily into a moist powder, or into a mash, depending upon the quantity of water used ; in any case it becomes soft enough to be eaten by the animal conveniently.

All cakes are liable to become mouldy if stored badly and in this condition are unfit for feeding. They should as far as possible be fresh (or quite fresh as in the case of cocoanut oilcake) and for this purpose should be stored under conditions which will thoroughly exclude moisture and will preserve them dry.

It will be also advisable to make up the oilcake ration with a mixture of two or three kinds of cake rather than feed all the ration in the form of any one kind of cake. This is recommended because as explained more than once in these pages, oilcakes (and in fact the pulses and grains as well) exert beneficial effects on the system which are not always revealed by their chemical composition in respect of the content of nitrogen or other constituent.

VIII

MISCELLANEOUS AND EMERGENCY FODDERS AND MINERALS IN FEEDS

THE different kinds of cattle feeds which we have considered so far practically exhaust the list of feeds and fodders usually fed in this country. There are however some others which may be referred to as special, or miscellaneous fodders. For the sake of completeness we shall now briefly deal with these feeds also. These comprise firstly the molasses of cane sugar, secondly various fruits and leaves, thirdly emergency or distress fodders.

Cane Sugar Molasses.—This material is obtained as an important bye-product in the making of sugar, whether in large factories where white sugar is made or in the small establishments where indigenous sugars called *khandasari* sugar or *boora* sugar are made. Fresh molasses will contain all the liquid uncrystallisable sugar (called glucose) in the cane, a considerable quantity of cane sugar itself held in solution, together with some of the mineral ingredients originally present in the cane juice and some which come in during the process of manufacture, all mixed up along with varying quantities of water; it is a viscous, sticky fluid, thick or thin according to circumstances, exceedingly sweet and as ordinarily available, with a somewhat pleasantly alcoholic smell; this of couse is due to the fermentation which the sugars have undergone during the period of storage however small this might be. The total sugar content of molasses is very high though somewhat variable. The old somewhat crude methods of sugar-making such as are adopted in making *boora* sugar yield a product rich in sugar, but in the factories the removal or recovery of sugar is more thorough and the molasses are low in sugar content. In fact the more efficient the sugar-making the less rich are the molasses. Molasses are sometimes available in two or three grades such as first, second and third molasses, these are exhausted of sugar in an ascending order of thoroughness. Molasses rich in sugar may contain 70 per cent. of which the cane

sugar proper (called sucrose) may be some 50 per cent.; in inferior or well exhausted molasses, the sugar content may go down to 60 per cent. with the liquid sugar or glucose largely predominating, to the extent of some 30 per cent., the remainder being cane sugar. Molasses also contain a high ash or mineral content, which may amount to about 5 or 6 per cent. Owing to the viscous condition of the product molasses are a messy stuff and difficult to handle and transport; hence it is only in the neighbourhood of factories that it can be conveniently utilised as a cattle feed. In its fluid form, feeding too is inconvenient. To get over these difficulties, molasses are mixed with some kind of filler, such as powdered cane bagasse (*i.e.*, the refuse after the cane has been crushed), or some kind of chopped up coarse fodder like straw, hay, etc., and then pressed and put up in briquettes, sometimes under the name "molasscuit". When fed by itself about 2 lbs. per animal per day is generally recommended. Molasses serve two purposes, *viz.*, as a direct rich and nourishing food, and as an appetiser, making other fodders more palatable.

Fruits, Pods and Leaves.—While it need hardly be stated that all edible fruits fit for human consumption are eaten by cattle as well, it should be pointed out that some of these possess strong and characteristic odours which are imparted to the milk of the animals consuming such fruits; these odours are highly objectionable in milk and for this reason such fruits have to be avoided. It is also the practice to feed cattle on fruits which may have partially rotted or otherwise become unsuitable for human consumption. Such fruits are also likely to impart to the milk objectionable odours, even though it may be supposed that they do no harm to the health of the animal. It will be better policy to treat dairy animals more like humans in this respect and to refrain from feeding them on such fruits.

Among the fruits and pods which are of use only as cattle feeds may be mentioned: (1) the pods of the babul (*Acacia arabica*), (2) the korkapalli (*Pithacolobium dulce*), (3) the rain tree (*Pithacolobium saman*), (4) the

mesquit (*Prosopis glandulosa*). The first two are well known and are much sought after. The fruits of the rain tree may be regarded as a novelty, and its value as cattle feed is not recognised yet. The tree has become very common on account of its great merits as a quick growing shade tree and is now a great favourite both for avenues and for planting as single specimens. In the season, the ripe fruits drop in great numbers and strew the ground under the trees thickly. Cattle now eat these fruits with avidity, though they used to be left untouched not many years ago. They are very sweet and a recent analysis puts down the carbohydrate content at 48 per-cent. and the crude protein content at 11 per cent. The content of fibre is however high, *viz.*, 27 per cent. The mesquit tree is almost unknown in South India but is met with in large numbers in North India. Its ripe pods are also very sweet and cattle will eat them readily. The tree deserves to become better known and popular.

Of other fruits, pods and berries both trees and bushes in our forests produce a great variety and in profusion and in the season certainly afford material sustenance to cattle therein; little however is known about these to warrant anything more than this brief mention.

The leaves of a number of trees form excellent fodder and if allowed to do so animals will eat them with great relish. Indeed animals become accustomed to certain leaves to such an extent that they will not touch even green grass. A curious type of cattle living exclusively on the leaves of the *chujjili* or *Albizzia amara* have been reported to be found in the hills on the Salem border of Mysore. Likewise the thorny bush *Zizyphus jujube* or the '*ber*' fruit plant is said to be greedily eaten by dairy cattle in Upper India, especially in Bikaner, where it is said to form almost the sole green fodder available to these animals. It is indeed stated that it greatly conduces to a good milk yield. In the Appendix is given a list of some of the trees and shrubs in Mysore which are of fodder value.

There are other trees whose leaves animals will eat, when anything better cannot be had, and of these the number is very large. There are others again which

may be called famine feeds which animals will not touch ordinarily and are driven to do so on account of hunger. These leaves possess some special odour or they taste bitter, both of which repel cattle under ordinary conditions. It is a matter for research whether these cannot be rendered edible by some kind of cheap treatment which will have the effect of removing the smell and the bitterness in taste ; it may be observed that these are due to the presence of some strong smelling essential oils or of some alkaloids, neither of which should prove difficult of removal or neutralisation by comparatively cheap methods. Successful attempts in this direction will make very large supplies of good fodder available in the country.

The emergency or distress fodders.—In times of fodder scarcity when on account of the failure of rains over one or two seasons the usual dry fodder, *viz.*, the straws of the different grains are not to be had and when the ordinary waste lands and grazing grounds are bare, cattle have to be fed on various emergency or distress fodders, like those mentioned above, *viz.*, the leaves of various trees and bushes which are ordinarily not touched. A list of the different kinds of tree fodders is given in the Appendix. In addition it may be mentioned that in Mysore the leaves of the wild date trees are largely fed at such times and these trees are severely lopped for the purpose. Another tree is the kamara (*Hardwickia binata*) of which large plantations are maintained by the Forest Department, and these are systematically lopped for the sake of the leaf fodder at such times. At one time the prickly pear was also put to the same use, as is referred to below, although all the prickly pear bushes in the country have been completely exterminated, due to the cochineal insect which was introduced by the Agricultural Department purposely for its destruction as noxious vegetation.

Fodder Distress Relief Measures

It is one of the misfortunes of the country that there occur periodically fodder famines of great severity, consequent on the failure of rains over one or two

'Cramming' fodder jowar to bullocks, a common practice in Mysore.

Photo by Author

Date groves. almost ruined by the cutting down of the leaves for fodder, during a fodder distress in Mysore.

—Photo by Author

seasons consecutively. The distress becomes very acute in the tracts where no great irrigation works exist and which therefore depend upon dry farming or dry farming supplemented by well irrigation. If rains fail for two seasons consecutively then even these wells fail and no cultivation can be carried on. It then becomes necessary to adopt very elaborate measures for relieving the distress and save the cattle. It will be useful to refer to the measures that should be taken towards this end, so as to give an idea of the campaign that may be necessary, not indeed to save all the cattle but at least to save the costly plough, cart and *kapile* bullocks and the cows of the better type which form the foundation stock, especially in a great breeding country like Mysore.

During the years 1923 and 1924 a terrible fodder famine occurred in this State and the eastern parts of the State which depended on well cultivation very largely felt the full force of the distress. Straw stocks were quite exhausted and no fresh supply was available; wells large and small dried up and even those which had had not dried up within living memory failed. Valuable arecanut gardens of great age were ruined for lack of irrigation. Forest plantations in the plains had no grass or under-growth owing to the failure of rains, the open wastelands were quite bare and dried up, tree leaves like neem, the wild date, the avenue trees consisting of different *ficus* varieties were fed and even these came to an end and cattle perished in great numbers. Indeed according to the cattle census of the quinquennium following the distress quite 50 per cent. of bovine cattle had perished, unbelievable as it may seem. Cattle in farmers' houses underwent continuous starvation and dropped down from exhaustion to rise no more. The situation was unparalleled in its severity and pathetic in the extreme. A number of relief measures were set on foot, with the object of mitigating the suffering and loss and we shall now make a brief reference to them in bare outline, so that they may indicate what may be attempted should the occasion arise for them in the future either in Mysore or elsewhere in India with similar local conditions. The measures were

aimed to secure the following different objects and accordingly fall into as many classes: —

1. Bringing paddy straw fodder from the channel fed paddy tracts into the distress tracts.
2. Shifting cattle from the distress tracts to the malnad forest pastures.
3. Provision of emergency fodder camps in the distress tracts.
4. Cutting forest grasses in the malnad forests, drying and baling them and transporting them to the distress tracts.
5. Encouraging the cultivation of fodder juar in the channel tracts after the harvest of paddy so as to release paddy straw for the distress tracts.
6. Improvement and deepening of wells.

Each of these may now be described briefly.

1. *Bringing paddy straw from the channel tracts.*—The only areas which could furnish straw were the channel tracts of the Mysore District, and arrangements were made: (*a*) to buy the straw in the villages, (*b*) to stack it at several convenient railheads, (c) to open two large storage and distribution centres, to which the straw would be railed and from which it would be sold to ryots who would take them in their own carts. One centre was in Bangalore and the other in the heart of the distress tract, *viz.*, Goribidnur. The stack yards at both centres were large open places; they were fenced round with barbed wire fencing, stack platforms were erected of jungle wood, arrangements were made for plenty of water in the event of a fire and watch and ward also provided against the same danger. Straw was first stacked loose but was later on pressed into bales, for which an electric motor and a baling press were installed.

The rail transport was very difficult. Straw had to be railed from several loading centres and the provision of waggons was difficult to manage. It was brought in generally in full train loads, the whole rake comprising only straw waggons with the exception of course of the engine and guard van. Straw had to be loaded loose and that reduced the capacity of the waggons very much. A baling press was later installed in the largest loading

station and that helped a great deal; in fact baling is so essential in this behalf that one should be prepared with the requisite equipment.

2. *The marching camps.*—The next measure was the marching of cattle to the malnad forests from the distress tracts. For this purpose all along the route at convenient stages, camps were opened where water for drinking, and some straw fodder were provided, together with shelter for the men in charge. Cattle were marched in batches to the pasture grounds where special arrangements were made for their being looked after and protected against tigers and cheetahs. They were marched back to their villages when after a few months good rains fell and fortunately the situation improved. Cattle were marched mostly from the Maddagiri taluk to the Lakkavalli forest.

3. *Emergency fodder camps.*—All over the distress tracts in the important villages, small camps were opened where prickly pear leaves were prepared for feeding by the method of pulling out the rosette of fine thorns on them and by the method of burning off the thorns over fire in a small forge. The leaves so prepared in either way were then chaffed, mixed with groundnut oilcake powder and fed to the animals. These served also as demonstration centres where ryots could see the two methods and adopt whichever was convenient to them.

4. *Encouraging the cultivation of fodder juar in the channel tracts.*—The paddy lands in the channel tracts being only single crop lands, the fields lie fallow after the crop of paddy is harvested and it is generally possible to grow on these fields fodder juar as a two or three months' crop. Water was let into some of the channels to facilitate the cultivation so as to give two or three irrigations. It had the two-fold object of releasing paddy straw for the famine tracts and also serving as the first step in introducing the practice of growing green fodder after paddy in these fields.

5. *Cutting malnad grasses for being sent to the distress tracts.*—There is always an abundance of grass in these forests which ordinarily is not made use of and which simply seeds and dries up at the end of the season. It is

in fact a great reserve, which can be drawn upon during such emergencies, provided it is cut, dried and transported in bales wherever it may be required. It is indeed often urged and very rightly that a large reserve or buffer stocks of such hay should be built up, as a kind of insurance against famines. A beginning was however made in bringing in baled hay from these forests to meet the emergency, leaving aside the question of making it an annual operation as an insurance measure to be tackled later on. This is a very important measure and, despite cost or other difficulties, deserves to be worked as a regular annual routine in the forests. From the forest point of view it will at least clean up these areas and render them less liable to fire.

6. *Deepening wells.*—Hand in hand with these measures an organisation was set up for helping ryots to deepen the irrigation wells in the tract with the object of restoring if possible the inflow of water. In many cases improvement does result by such deepening, but surprisingly enough it was found that many wells had been repeatedly deepened during previous shortages and that the limit of the water-bearing stratum had already been reached. There were however other wells which were amenable to such treatment but which could not be taken up because the ryots did not possess the outfit required. Well sinking appliances, well curbs, pumps and engines for unwatering wells as the deepening progressed for avoiding the danger of the caving in of the sides and so on were all part of the facilities provided.

MINERALS OR ASH INGREDIENTS IN CATTLE FEED

Though not coming strictly within the scope of feeds and fodders, the question of the supply in adequate quantities of certain mineral or ash ingredients to all animals generally and to dairy cattle in particular is closely connected with the subject and is one of great importance. The subject has already been referred to in connection with the cattle diseases which may be brought on owing to the insufficiency of particular mineral elements in pastures. We shall here deal with the minerals or mixtures which usually

form part of the normal feeds provided to animals as part of the daily rations. The mineral composition of the animal body and of all animal products is made up of a large number of elements, all of which are derived from the various feeds which the animal consumes. All these are essential and indispensable in the animal system, and a sufficient quantity has to be present not only for the normal functions and needs of the system, but also when the body is building up new tissue as in the case of a young growing animal, or producing a large quantity of milk as in the case of a heavy milking cow, or has to nourish and develop a growing fœtus, as in the case of a pregnant animal. It will be interesting to note that a curious fact found by experiments with animals, is "that if an animal is fed a ration supplying an abundance of other food material but no mineral matter, it will die quicker than if given no food at all" (Clarence H. Eccles). Now, it happens that although the elements comprising the ash content are large in number, yet the elements which have to be supplemented and given separately are only very few; the others are usually present in sufficient quantities in the feeds themselves. These are only four in number, *viz.*, sodium, calcium, chlorine and phosphorus, although now and again the claims of some others, such as sulphur, iodine, manganese, iron, copper, etc., are also stressed (*vide* page 21). This is however, only in very rare circumstances.

Common salt.—Of these sodium and chlorine are supplied in the shape of common salt (sodium chloride). Common salt may really be considered the most important in this respect and is the one almost invariably given along with the ordinary daily ration. Animals will quickly be affected if salt is withheld, and although they may carry on for some time thereafter in a state of low vitality, a poor general condition and emaciation will follow, which may lead to the death of the animals. An insufficiency however may give rise to certain depraved habits like the sucking of its own urine, and produce greater susceptibility to tick attack and a much lowered stamina to withstand unfavourable conditions. Normally common salt in the ration is a good

appetiser, increases the desire for the drinking of water, enhances the flow of the digestive secretions, purifies the blood and acts almost like a daily tonic. In nature animals satisfy their craving for salt by licking salt from the earth, for which they may even trek long distances to places where these " salt licks " may be found. It is a striking sight in Mysore to see herds of cattle from the Shimoga malnad in the most pitiably miserable condition being led to the "salt licks" in the Kadur taluk, after the rains have ceased and a salt incrustation forms on those particular soils. In ordinary dairy practice salt is given either by keeping a lump of rock salt close to each animal which it can lick whenever it wants or by an addition of a small quantity with the daily ration. The latter is a better practice, for the reason that animals get the quantity which is good for them, neither more nor less ; animals differ greatly in their liking for salt and it has been found in experiments that, if left free to lick, one animal may eat three times as much as another, a quantity which does more harm than good. About 1 oz. to 2 oz. of salt daily given along with the ration will be found ample in the case of animals in heavy milk.

Calcium and phosphorus are the other most important elements in this class. The two together form calcium phosphate, of which the bony skeleton is largely made up and are therefore very much in need by the system for the building up of these tissues as in the case of growing animals and for maintaining the proper condition and strength of the bones in adult animals. In the case of milking animals and those in calf, there is a great demand for the elements in the system and the drain of these elements has to be continuously made good by additions in the ration. The blood in the system must maintain a certain level in its content of these elements for the normal function, for meeting the demand for growth and milk production and for the retention of fecundity unimpaired. Deficiency diseases like weak bones, fragile bones, stunted growth, or osteomalacea, decreased milk production, sterility, the habit of bone chewing, etc., are the result of an insufficiency of these elements. Indeed the importance of

these elements can hardly be over estimated. Although good hay and leguminous herbage provide fair amounts normally, it will be an advantage to supplement them by additions in the rations.

The two elements are furnished in the form of pure phosphate of lime (dicalcium phosphate) or of bonemeal. The bonemeal used for this purpose is however specially prepared, and is a sterilised product. About $\frac{2}{3}$ to 2 oz. of the phosphate or 1 to 3 oz. of the bonemeal form a good allowance and can be given mixed with the ration daily. The higher proportion is of course for animals giving very large quantities of milk. Sometimes the phosphate allowance is made up of only one half phosphate, the other half is made up of well-ground limestone.

There are on the market quite a number of made-up "licks" which contain in addition to these elements a few others such as sulphur, iodine, etc., but the need for and the real value of these may be doubted. Some of these "licks" are in the nature of a medicinal preparation. Special mention may however be made of the role of iodine in this connection. Recent researches have shown that the production of milk can be materially stimulated by extracts of the thyroid gland or the compound iodinated protein, which is the essential and effective substance responsible for the stimulation and increased production and which can be artificially produced. There seems to be no doubt that an increase in the milk yield can be secured by the feeding of this compound, although opinions are divided as to the wisdom of accelerating the function in this way which may prove detrimental to the normal or permanent yielding capacity of the animal during the further span of her life.

IX

RATIONS AND SOME GENERAL PRINCIPLES OF MAKING THEM UP

In this the concluding chapter, we shall explain the general principles which are followed in the making up of rations for different classes of dairy cattle and also give a list of some typical rations which are adopted in some of the dairy and other farms under Government control in different parts of India. We may say by way of preface that these principles can be explained only in a very general manner, firstly, because anything more detailed is beyond the scope of these popular articles and, secondly, because the subject of animal feeding in many of its important aspects awaits scientific research and a great portion of what is taught and recommended is based upon the results of foreign research, which it is presumed will be generally applicable to Indian conditions also. The subject is perhaps the most fruitful field of research both on account of the vast field that it opens out and also on account of the immense importance of the results that may be achieved. We may note with pleasure in this connection that a great deal of research work is under weigh in the field of both human and animal nutrition in our country which eventually is bound to widen our knowledge and make it more accurate.

We may first explain some of the elementary technical terms we have used in describing the composition of the feeding materials which we have considered, though it may be somewhat superfluous to do so at this stage. The proximate composition of all these feeds and fodders is given in terms of carbohydrates, fats, proteids, crude fibre and ash or minerals, and of water or moisture. All the food elements proper, *i.e.*, all except the water, comprise many components each, whose character and quantity greatly influence or modify the food value of the proximate constituent of which it forms a part. In the main they influence the digestibility of the material; thus though the carbohydrates and the crude fibre are very similar in composition, they differ materially in respect of

their digestibility and therefore of their usefulness. A further factor in the extent of their usefulness is introduced by the kind of animal consuming the food, whether humans or cattle, and even within these classes upon the breeds and of individuals therein. Thus milk sugar, fruit sugar, cane sugar, starches of different kinds, the cellulose framework of straws, and even wood fibre and tissues, all belong to the class 'carbohydrates' but their digestibility and therefore value in nutrition are very widely different from each other. Indian breeds of cattle moreover are known to be able to make use of the coarse straws to a larger degree than European breeds of cattle. Similarly in respect of fats, though their general composition is of the same type, the different kinds differ widely in their more intimate make-up with corresponding differences in their digestibility or suitability to different animals. The oils of gingelly, linseed, olive, cocoanut and groundnuts among vegetable fats, butter, lard, suet, tallow, whale oil, etc., among animal fats, have only to be mentioned to bring out the differences which exist. In the same way, among the so-called proteids there is a wide array of compounds, derived from both the animal and vegetable kingdoms, with numerous different kinds in each of these sources. All these too, although they possess a general similarity in composition, principally in the fact that they contain nitrogen, differ widely in many other respects, including their suitability as foods. It is the function of future research to go more deeply into the character and composition of the more intimate components. In addition to these food elements, well known for a long time, are the vitamins, whose existence and functions are matters of recent knowledge and which are now known to possess properties profoundly affecting the health and growth of animals.

The carbohydrates and fats are generally termed 'heat producers' ; and their comparative values in this respect are expressed in terms of 'calories' or heat units, the number of which gives a measure of the heat-producing value. It is usual to compare the animal system with a steam engine in this respect, and these food elements to the fuel in the engine ; just as the latter by being burnt

liberate and furnish the power which drives the engine, so these food elements by being oxidised (a process which in essence is the same as burning) in the animal system furnish the heat and the energy required to carry on the essential life-processes and to enable the animal to perform work and to manufacture in its system the products for which it is kept. The proteids on the other hand discharge another function in addition, *viz.*, the building up of tissue, whether in actual growth or in the repair of waste. In view of the fact that this property is possessed only by the proteids and not by the others, the proteids are distinguished by the name 'flesh formers'. The proteids are very complex in composition, and some may contain sulphur, phosphorus and iron as well in addition to nitrogen which is their distinguishing constituent. Their molecular weights are remarkably high, as compared with ordinary substances and even with many carbohydrates and fats, that of egg albumin for instance being put down as 5,378 and of serum albumin as 10,1666! Animal proteins are different from vegetable proteins, and there are very sharp and important individual differences between them, the bearing of which in this connection is that one protein cannot exactly replace another, as food in the system. Chemically they all break down by hydrolysis into compounds of gradually lessening complexity into a mixture of a number of "amino-acids". The nature and amount of such amino-acids so obtained determine the property peculiar to the particular protein. Glycin, leucin, tyrosin, cystin, aspartic acid, lysin, histidin and tryptophan are some of these different kinds of amino-acids, into which we cannot go further than merely mentioning them by name. An interesting experiment is often referred to in this connection, *viz.*, that rats which were fed with zein (the protein of maize) as the source of protein in the feed continued to lose weight while with a little addition of meat (or animal) protein they began to rapidly gain weight, which shows that although protein was fed in the shape of zein, it was not the protein wanted (*viz.*, tryptophan) which was supplied only by the meat or animal protein. It is an extraordinary

circumstance that bovine cattle are credited with the property of utilising the nitrogen of compounds like sulphate of ammonia and urea for building up proteids through the agency of certain bacteria present in their rumen or large stomach. We are however not aware if any practical application has been made of this finding in the feeding of animals. It may be stated that the fats also form a reserve material in the system and when more food is fed than is necessary, whether it be carbohydrates or fats or proteids, the excess is stored as fats in the body. The vitamins (which are distinguished as A, B, C, D, E and so on) perform very essential functions also, and the absence of one or more of them leads to diseases like weak bones, scurvy, beriberi, sterility, night blindness, etc., which on this account are called 'deficiency diseases'. About the functions of the mineral elements in the food we have already explained in a previous chapter.

Bovine Digestion

The process of digestion with special reference to bovines may now be briefly described.

The organ concerned in the digestion of the food is the alimentary canal which comprises several distinct parts, *viz.*, the mouth, the œsophagus, the stomach, the small intestines, the large intestines and the rectum. The food after it is taken into the mouth passes successively through these parts, being subjected to both mechanical and chemical action during such transit. After digestion is completed or after the digestive organs have removed and absorbed from it whatever can be digested, the residue is ejected outside as excreta. Secretions containing enzymes which are essential in effecting certain changes in the food are supplied by the organ pancreas and the gall-bladder which can therefore be included among the organs of digestion. The nature of the stomach in the bovines is peculiar and different from those in other animals. While in the latter the stomach is single and is just one pouch-like cavity, in the bovines the stomach is multiple and comprises four successive pouches. The first one (called rumen or paunch) is the largest of the four;

it is followed by a small one called reticulum, which is followed by another pouch called omasum which leads to the last of the four called abomasum which is the *true stomach*. All take part in the digestion.

The changes which the food undergoes in each of these different parts of the alimentary canal are as follows:— In the mouth the food is masticated, crushed or mechanically reduced to a finer condition and mixed intimately with saliva which is secreted in the mouth; at the same time it is acted upon by the enzyme ptyalin which is contained in the saliva and which converts the insoluble starch to sugar the soluble absorbable form. During the time the food remains in the mouth both when first taken and later during rumination (as explained below) this digestion of the carbohydrate (*viz.*, starch) goes on. After this physical process and the chemical process of converting the starch into sugar and its absorption, the food passes down into the region of the stomach. The rumen or paunch is mainly a storage chamber in which the partially crushed food is stored preparatory to a further crushing in the mouth, and thereafter to be passed forward. For this second crushing, after the animal has finished feeding, she begins to rest, and this food from the rumen is forced back or "regurgitated" into the mouth where this further crushing takes place in the process of "chewing the cud". The "chewed cud" or food so ground further is then passed down, not back into the rumen but into the second stomach or omasun, which selective passing down is effected by the special arrangement at the entrance to the paunch. More food is forced up into the mouth for chewing, and after this is chewed and sent down into the second stomach the process begins again and continues in this manner until the whole of the contents of the rumen are disposed of. In the second and third stomach the main process is one of further physical breaking down of the food by being crushed finer and finer or the cellulose framework of the food material is broken down.

The food next passes into the fourth or true stomach. In this stomach the digestion of the proteid compounds commences. The inner membrane of this stomach secretes

gastric juice which contains hydrochloric acid and the enzyme pepsin, which has the property in an acid medium of breaking down the complex insoluble proteids into less complex soluble peptones, which are absorbed and carried away by blood vessels into the general system. The physical action of further grinding up also takes place at the same time.

The food in this condition, *i.e.*, with part of the carbohydrates and of the proteids having been digested and physically reduced into a pulpy mass, is forced further on into the smaller intestines. Into these intestines are secreted pancreatic juice from the pancreas—a ductless gland, and bile from the gall-bladder through the bile duct. The former contains three important enzymes, which act respectively on the proteids, starches, and the fats. The bile contains a fat saponifying enzyme, rendering the fat soluble. It also neutralises the acidity of the food as it passes out of the true stomach into the intestines and makes the medium suitable for the action of the various enzymes in the intestinal tract. In the intestines are also secreted enzymes capable of 'inverting' or splitting the higher sugars like cane sugar, maltose or lactose into the lower ones like glucose and dextrose. In the presence of these various active enzymes and during the prolonged passage through the intestine small and large, important chemical changes take place which have the effect in their totality of rendering all the nutrients left over from gastric digestion—such as the proteid and carbohydrates of various kinds—and the fats, into simple and easily absorbable compounds. The portion of the food which has resisted all these digestive juices and the various products formed during the chemical action both solid, liquid and gaseous which cannot be absorbed by the body are voided as excreta. The mechanical action involved in the continued and prolonged contraction (peristaltic) of the whole alimentary tract which result in both a churning up of the contents and a continuous propulsion forward is a very important energy consuming activity; while equally great is that involved in the various secretions by the cells and the

chemical action involved in the breaking down and the building up of compounds also consume energy.

In addition to the enzymes and the chemical agents which bring about these changes in the food various bacteria and protozoa are also responsible for certain changes. Thus in the rumen there is a considerable bacterial flora and these bring about a breaking down and even solution of the cellulose which has the result of unlocking the nutrients inside these hard walls to the action of the digestive juices. Bacteria are also responsible for utilising inorganic nitrogen in the form of urea and sulphate of ammonia especially for their own growth and thereby synthesising proteins which the animal body can make use of.

Animals have to be fed with the proper quantities of food and they are adjusted to the special needs of the animal ; that is, according as it is young, and growing, in milk or pregnant, or only dry or in the case of working animals as they are doing heavy work or merely at rest. The foods have to be adjusted too according to their body weight, and to the quantities of milk they may be giving. A ration which supplies all the different food elements and in the correct proportion is generally called a balanced ration ; and if good results are to be attained, such a ration has to be provided. In most cases the adjustment relates to varying the proportion of the 'heat producers' to the 'flesh formers' in the foods provided. If the animal is young and growing, if the animal is in heavy milk, or in the case of working animals if they are doing heavy work, then a higer proportion of proteids or 'flesh formers' to the 'heat producers' is provided, in order to build up the new tissues and to repair the waste. This proportion is referred to as the 'nutritive ratio'; it is spoken of as 'wide' or 'narrow' according as the proteids are low or high in proportion. A ratio of 1 of proteids to 10 or 15 of 'heat producers,' for example, will be very 'wide' and is often adopted for adult animals doing no work or cows which are dry and not in calf. A 'nutritive ratio' of 1 of proteids to, say, 3 of 'heat producers' will be a narrow ratio and is of the type adopted for

growing calves and cows in milk. These proportions are varied according to conditions in different ways.

It is not a difficult matter to calculate the nutritive ratio, provided the analyses of the foods are available. These figures of analysis give the percentage of carbohydrates, fats and proteids in the food, from which the quantities of these three in the foods selected may be calculated. The total quantity of 'heat producers' made up of the carbohydrates and the fats is calculated by first multiplying the fats by 2·25 and then adding this to the carbohydrate ; the sum of the two give the total 'heat producers'. The quantity of the proteids also being known, the ratio of the latter to the former is easy to work out. Sometimes analyses give the actual *digestible* percentages of these three food elements, and calculations on that basis are of course more accurate.

The total quantity of food which is required for any particular animal is generally reckoned on the basis of its body weight. Roughly for every 100 lbs. of body weight about $2\frac{1}{2}$ to 3 lbs. of food (in the dry condition) is considered necessary and the total quantity of food so reckoned should contain the two kinds 'heat producers' and 'flesh formers' in the proportion which is appropriate to the condition of the animal, *i.e.*, should have the correct nutritive ratio.

The ration of animals is also calculated in terms of a 'maintenance' ration and of a 'production' ration. The former is the quantity of food with its appropriate nutritive ratio which is required for the animal of a particular body weight to enable it to carry on merely its life-processes, *i.e.*, to enable it to just live. Over and above this ration the animal is given a 'production' ration which is exactly suited to what it is producing by way of work or products like milk or growth tissue in the body. The 'production' ration also takes into account the actual quantities of the products like milk which the animal produces ; so that this part of the ration is in proportion to the quantity of milk yielded. The 'maintenance' ration has of course a 'wide' nutritive ratio which may go upto 1:15 and the food material largely consists of coarse

bulky fodders like straw. The 'production' ration has a very narrow nutritive ratio and is given in the shape of concentrated feeds like oil-cakes, cottonseed, etc. It is very necessary for the correct computation of rations to take note of the digestibility of the various feeds in respect of the carbohydrates and of the proteins in them. Only varying fractions of these constituents become useful to the animal depending upon the proportion which can be actually digested; this fraction or percentage forms, so to speak, the available quantity of the constituent as against the total quantity which may be indicated by an analysis. How much is really thus digestible or available can be determined only by means of actual feeding experiments on animals or sometimes, as a shortcut which can be used to some extent as a check, by means of laboratory experiments (*in vitro*) in which the material is subjected to the action of the particular digestive fluid such as ptyalin, diastase, pepsin, and so on—a method which imitates more or less the actual digestive processes in the body of the animal. "Digestible coefficients" are thus worked out for many kinds of feeds and of these comprehensive lists are to be had for European and American feeds and conditions but only to a small number in the case of India. It is from such figures as are available therefore that the nutritive ratio will have to be worked out, the ratio applying in strictness only to the 'digestible' carbohydrates and 'digestible' proteids. It is however interesting to note that animals may digest and assimilate more in some combinations of feeds than in others, so that the combination or components of the feeds influence their assimilation to some extent. (A very handy and useful book of reference in this connection is *Bulletin No. 25 of the I.C.A.R.*, by Dr. K. C. Sen, already mentioned on page 62).

Some useful rations.—We have explained just the rudiments of the principles of feeding as anything more should be considered beyond the scope of these popular articles. We now present a number of rations for dairy and other cattle which have been prescribed in some of the Government Dairies in India, with our grateful acknowledgements to the various institutions.

Ration I

Agricultural College Dairy, Coimbatore.

Class of animal		Groundnut cake	Cotton seed	Rice bran	Dhall husk	Salt	Mineral mixture
	lbs. a day	lbs.	lbs.	lbs.	lbs.	oz.	oz.
A. Milking	25—30 ..	3	3	2	3	2	2
B. ,,	20—25 ..	2½	2½	2	2½	2	2
C. ,,	15—20 ..	2	2	2	2	2	2
D. ,,	10—15 ..	1½	1½	2	1½	2	2
E. ,,	5—10 ..	1½	1	1	1½	2	2

It will be seen that in contrast with the ration I published above, a larger variety of feeding stuffs is included in this ration.

All the animals are fed with 55 lbs. of Guinea grass per day, as the bulky feed.

The mineral mixture is made up of equal parts by weight of ground shell lime and steamed bone-meal. (From *M.A.S.U. Journal.*)

Ration II

Table of feed adopted in the Government Dairy Farm, Hebbal:—

1. (*a*) *Milch Cows* giving over 40 lbs. a day (Live weight 750 lbs.).

Concentrates :

Groundnut cake ..	.. 6 lbs.
Rice bran ..	.. 4 ,,
Horsegram (crushed) ..	.. 2 ,,
	12 lbs.

Gram Husk 1 lb. per day.

In addition to the above 40 lbs. of hay or silage with grazing.

(b) *Milch Cows* giving below 5 lbs. a day.

Groundnut cake	.. ..	$2\frac{1}{4}$ lbs.
Rice bran	.. ..	$1\frac{1}{2}$,,
Horsegram (crushed)	.. ..	$\frac{1}{4}$,,
		4 lbs.

with 40 lbs. of hay or silage with grazing. Gram husk 1 lb. per day per animal.

2. *Dry Cows.*—

Concentrates:

Groundnut cake	..	$1\frac{1}{2}$ lbs.
Rice bran ..	..	1 ,,
Horsegram (crushed)	..	$\frac{1}{2}$,,
		3 lbs.

with 30 to 40 lbs. of silage and grazing.

3. *Cows nearing parturition* get 3 lbs. of more concentrates than dry cows in the same proportion as in 2 after the seventh month till calving.

4. *Breeding Bulls* (Live weight 800 lbs.).—

Groundnut cake	..	$2\frac{1}{4}$ lbs.
Rice bran ..	..	$1\frac{1}{2}$,,
Horsegram (crushed)	..	$2\frac{1}{4}$,,
		6 lbs.

with 40 to 60 lbs. of fodder and grazing.

5. and 6. *Yearling Heifers and Bulls.*—

Groundnut cake	..	2 lbs.
Rice bran ..	..	1 ,,
Horsegram (crushed)	..	1 ,,
		4 lbs.

Fodder 20 to 30 lbs. with grazing.

7. *Calves.*—

Age	Whole milk per day	Concentrates	Salts	Remarks
Below 1 month ..	4 lbs.	—	—	Per day
Below 2 to 4 months ..	3 lbs.	1 lb.	1 oz.	,,
Below 4 to 6 months ..	2 lbs.	2 lbs.	1 oz.	,,
Below 6 to 12 months ..	Nil.	3 lbs.	1 oz.	,,

Grazing is allowed in the Napier Grass pasture after 2 months.

Remarks.—For all adult animals a mineral mixture of 2 per cent. of common salt and 1 per cent. bone-meal is given daily. Rock salt is always available before the animals.

Ration III

Ration at the Imperial Dairy Institute, Bangalore, for the month of April 1942

(Calves and young stock omitted)

Name of ration	Maintenance ration						Production ration		
Class of animal	Dry Fodder		Green Fodder				Grains		
	Ragi straw	Guinea grass	Rhodes grass	Lucerne	G.N. cake	Gram husk	Con. mixture	Wheat bran	Salt
Cows.—	lbs.	lbs.	lbs-	lbs.	lbs.	lbs.	lbs.	lbs.	oz.
Milking 45 lbs. snd over ...	3	20	21	...	½	½	22½	...	1
40—45 lbs. a day ...	3	20	21	...	½	½	21½	...	1
40—42 „ ...	3	20	21	...	½	½	20	...	1
37—39 „ ..	3	20	21	...	½	½	18½	...	1
34—36 „ ...	3	20	21	...	½	½	17	...	1
31—33 „ ...	3	20	21	...	½	½	15½	...	1
28—30 „ ...	3	20	21	...	½	½	14	...	1
25—27 „ ...	3	20	21	...	½	½	12	...	1
22—24 „ ...	3	20	21	...	½	½	11	...	1
19—21 „ ...	3	20	21	...	½	½	9½	...	1
16—18 „ ..	3	20	21	...	½	½	8	...	1
13—15 „ ...	3	20	21	...	½	½	6½	...	1
10—12 „ ...	3	20	21	...	½	½	5	...	1
8 lbs. and under ...	3	20	21	...	½	½	4	...	1

Dry cows ..	3	20	21	...	½	½	3	...	1
Cows down calves (4 weeks before they calve) ...	3	20	21	...	½	½	3	3	1
Cow calved 1st 3 days ...	3	20	21	...	...	...	...	8	1
Buffaloes.—									
Buffalo milking 30 lbs. daily ..	3	25	31	...	¼	1	18	...	1
Buffalo dry ...	3	25	31	...	¼	1	4	...	1
„ down calves ..	3	25	31	...	...	...	3	4	1
„ calved 1st 3 days ...	3	25	31	...	...	...	...	10	1

Remarks.—Composition of concentrate ration for milk production including service pregnancy dry stock and growth :

Wheat bran ...	... ... 4 lbs.
Groundnut cake ...	... ... 2½ lbs.
Gram husk ...	... ... 2 lbs.
Gram crushed ...	... ... 1½ lbs.
Total	.. 10 lbs.

Proportion of feeding to cows 1 lb. of mixture for 2 lbs. milk.
Buffaloes 6 lbs. mixture for every 10 lbs. milk.

Ration IV

Rations for the Sahiwal herd at the Indian Agricultural Research Institute Dairy, New Delhi:—

Composition of Concentrates Rations

Mixture No. 1.—

Oats ..	..	$2\frac{1}{2}$ parts
Gram ..	..	$1\frac{1}{2}$,,
Groundnut cake	..	$\frac{1}{2}$,,
Linseed cake	..	$\frac{1}{2}$,,
Wheat bran ..	..	1 ,,
		6

Mixture No. 2.—

Oats ..	..	$2\frac{1}{2}$ parts
Gram ..	..	$1\frac{1}{2}$,,
Mustard oilcake	..	$\frac{1}{2}$,,
Wheat bran ..	..	1 ,,
Linseed cake	..	$\frac{1}{2}$,,
		6

SCALE OF CONCENTRATES, MIXTURE NO. 1

(*a*) Cows in milk get 1 lb. of concentrates for every 3 lb. of yield of milk, with a butter-fat content over 4 per cent., and 1 lb. of the same concentrate for every 3 lb. of yield of milk with a butter-fat content below 4 per cent. Mixture No. 1 is a well-balanced ration for this pedigree Sahiwal milch herd whose capacity of production is over 700 gallon standard.

(*b*) Pregnant cows from the 8th month to the end of 9th month 5 lb. per head, per day.

(*c*) Pregnant heifers from 7th month to the end of 9th month 5 lb. per head, per day.

(*d*) All pregnant stock after 9th month to calving 7 lb. per head, per day.

(*e*) Heifers under service age 3 lb. per head, per day.

Scale of Concentrates, Mixture No. 2

(*a*) Dry stock 2 lb. per head, per day.

(*b*) Pregnant heifers from service date to the end of 6th month 2½ lb. per head, per day.

(*c*) Pregnant cows from service date to the end of 7th month 2½ lb. per head, per day.

(*d*) Young bulls from 10 months old to service age 3 lb. per head, per day.

(*e*) Stud bulls 2 to 3 lb. per head, per day, according to the demand of services.

Composition of Concentrate Ration for Calves

Calves over 6 months.—

Oats	.. ..	2½ parts
Bran	.. ..	1½ ,,
Linseed cake	..	½ ,,
Barley (boiled)	..	½ ,,
		5

Calves under 6 months.—

Oats	.. ..	3 parts
Bran	.. ..	2 ,,
Linseed meal	..	½ ,,
Barley (boiled)	..	½ ,,
		6

Method of Feeding

Soak the concentrates for six hours before feeding and feed the cattle at the time of milking.

Every milch cattle is fed with 1 to 2 oz. of mineral flour or sterilized bone-meal for mineral deficiency. Mix the mineral feeds just before the concentrates are served out to cattle.

Fodder

Cows in milk 5 to 6 lb. dry and 40 to 60 lb. green, per head, per day (to be regulated according to the yield, size and conditions of grazing).

Dry cows, heifers, pregnant stock and stud bulls, 10 to 20 lb. dry and 20 to 30 lb. green, per head, per day (regulate according to the condition of grazing). Young bulls 8 to 10 lb. dry and 10 to 20 lb. green. Bullocks 15 to 20 lb. dry and the same quantity of green.

Ration V

Ration in the Rayanakere Palace Dairy Farm, Mysore: —

1. *Milch cattle.*—3 lb. maintenance, 1 lb. of the following mixture for 3 lb. milk: —

Mixture :—

Groundnut cake	..	3 lb.
Wheat bran ..	..	1 ,,
Rice bran ..	..	1½ ,,
Ragi, jola and broken rice mixture ..	..	1½ ,,
Horse gram ..	..	1 ,,
Gram husk ..	..	1 ,,
Bengal gram ..	..	½ ,,
Salt ..	..	4 oz.

for each cow.

2. *Cows heavy in calf.*—4 to 6 lb. each of the following mixture:

Mixture :—

Groundnut cake	..	3 lb.
Wheat bran ..	..	2 ,,
Rice bran ..	..	1 ,,
Salt (for each)	..	8 oz.

3. Two *Years calves*,—2 lb. each of the following mixture equal parts by weight of :—

Groundnut cake
Rice bran
Horse gram
} Salt ¾ oz. of each.

4. One *Year calves.*—1½ lb. each of the above mixture with ½ oz. salt each.

5. *Sucklings.*—for each.

Groundnut cake	..	1	lb.
Wheat bran ..	..	½	,,
Oats ..	..	½	,,
Salt ..	..	2	,,

Mineral supplements for all animals receiving concentrated rations at 2%.

Ration VI

Ration in the Live-Stock Research Station, Hosur Cattle Farm:

Rations for Dairy Cows

Particulars	Quantity of milk yielded lb.	Groundnut cake lbs.	Rice bran lb.	Bengal gram husk lb.	Cotton seed lb.	Salt oz.	Lime and Bonemeal oz.
Speciai ...	20 lb. and above	1-8	3-0	1-8	2-0	2	2
A Class ...	15-20 lb.	1-8	2-8	1-8	1-0	2	2
B Class ...	10-15 lb.	1-0	2-0	1-0	1-0	2	2
C Class ...	10 lb. and below	0-3	2-0	0-8	1-0	1	1
Cows nearing parturition		1-8	2-0	0-8	1-8	2	2

Ration for Calves

Age-Months	Ground-nut cake lb.	Rice bran lb.	Salt oz.	Lime and Bone-meal oz.	Whole Milk lb.	Gruel lb.
2 to 3 ...	¼	¼	¼	¼	6 to 8	3 to 4
3 to 4 ...	½	...	¼	¼	...	8
4 to 6 ...	¾	1½	½	½	...	8
6 to 9 ...	1	1½	½	½	...	10
9 to 12 ...	1	1½	¾	½	...	10

Gruel : To every 10 lb. of skimmed milk add 1 lb. of ragi flour *plus* 4 ounces of linseed.

Ration VII

For Sahiwal cow, weight 800 lb. giving 8 lb. of milk

North India:—

Wheat bhusa	2	lb.
Green maize	55	,,
Toria cake ..	1	,,

South India:—

Cumbu (green) (*Panicum typhoideum*)	60	lb.
Rape cake	1.25	,,

Ration VIII

Young growing animals of 400 lb. in weight

Green maize	30	lb.
Wheat bhusa	2	,,
Sesame cake	3	,,
Wheat bran	1	,,

Ration IX

For working bullocks 800 lb. weight and doing 6 hours of work a day

North India:—

Wheat bhusa	10	lb.
Maize green ..	23	,,
Cotton seed ..	1·5	,,

Ration X

South India:—

Jowar stalks	15	lb.
Rice bran	1	,,

Ration XI

Cumbu, green	40	lb.
Jowar staiks	5	,,
Gram husk ..	2	,,

(From "Trial Rations for Cattle", a note for the guidance of District Officers for computing standard or trial rations in their districts.)

Ration XII

Some Panjab Rations.

For buffalo 1,400 *lb. weight and giving* 20 *lb. of milk*

Wheat bhusa	..	20 lb.
Berseem green	..	2 ,,
Bengal gram	..	2 ,,
Toria cake ..	..	1 ,,
Cotton seed (43 F.)	..	4 ,,

Ration XIII

For cow of 800 *lb. weight and giving* 16 *lb. milk*

Wheat bhusa	..	8·5 lb.
Berseem green	..	3 ,,
Bajra	..	3 ,,
Bran	..	3 ,,

(Pandit L. C. Dharmani and others in *Indian Farming*, March 1946.)

Ration XIV

For buffalo giving 18 *lb. of milk and suckling her calf*

		lb. per day
Green fodder	..	10 to 15
Dry fodder	..	10 to 15
Cotton seed oil	..	3
Sesamum cake	..	3
Bran	..	3
Chuni (*Cajanus indicus* husk)	..	2
Salt ..	..	1 oz. to 2 oz.

(J. W. Mollison.)

APPENDIX I

LIST OF TREES AND SHRUBS OF FODDER VALLUE*

No.	Name	Remarks
1.	Bassia longifolia ..	.. Almost evergreen; the flowers, seeds and especially the young leaves are sparingly eaten by cattle.
2.	Bassia latifolia ..	.. Deciduous ; do
3.	Mangifera indica ..	.. Evergreen; tender leaves sparingly eaten.
4.	Spondias mangifera ..	.. Leaves generally well eaten.
5.	Moringa pterigosperma ..	.. Coppices excellently; leaves, flowers and fruits sparingly eaten.
6.	Cedrela toona ..	.. Though a malnad tree, could grow stunted in the maidans also; leaves well eaten.
7.	*Melia azederach* (Huchubevu)	.. Sparingly eaten.
8.	Garuga pinnata ..	.. Well eaten.
9.	Balanites roxburghii ..	.. Sparingly eaten.
10.	Erythroxylon monogynum (The Bastard sandal)	.. Grows in the poorest of soils; its leaves are greedily eaten by cattle. It is a very hardy species and is easily propogated. Even men are said to eat the dried leaves of this shrub reduced to a fine flour, when famine conditions prevail.
11.	Grewia oppositifolia	.. All Grewias are in general good forage plants; they thrive fairly well under dry conditions.
12.	G. tilæfolia	
13.	Gauzuma tomentosa ..	.. Leaves generally well eaten; is hardy and thrives well practically all over.
14.	Helictres isora	.. Greedily eaten by cattle, but generally deciduous.
15.	Flacourtia sepiaria (Maridi)	.. The leaves aoe eaten readily by cattle but the shrub is spinous.
16.	Michelia champaka ..	.. Leaves well eaten by cattle, but trees generally not lopped on account of the flowers.
17.	Ficus glomerata ..	.. The fruits are generally devoured by cattle.
18.	Ficus religiosa (The Sacred Banyan)	.. The leaves are readily eaten by cattle.
19.	Ficus infectoria ..	.. Leaves fairly well eaten.
20.	Ficus bengalensis ..	.. Leaves fairly well eaten.

21.	Tamerindus indica	The young leaves especially well eaten.
22.	Artocarpus integrifolia (The jack tree)	The leaves are generally well eaten.
23.	Sesbania grandiflora	Leaves, flower, etc., are generally devoured by cattle.
24.	Erythrina indica	Both leaves and flowers are well eaten; the tree is, however, prickly and deciduous.
25.	*Acacia arabica*	Grows in the poorest of soils. The tender pods and leaves are much relished by all sorts of cattle.
26.	Acacia leucophloea	Thrives in dry areas. The leaves, etc., are relished
27.	Eugenia jambolana	by cattle.
28.	*Albizzia lebbeck*	The leaves are sparingly eaten. The ieaves are greedilc eaten by cattle. The tree is, often said to be cultivated for forage.
29.	*Albizzia amara*	The leaves are very readily eaten by cattle. It thrives even under very dry conditions.
30.	*Thespesia populaes*	Deciduous. Leaves are sparingly eaten.
31.	Poinciana regia (The Gold Mohur Tree)	This is doubtfully useful as a fodder tree.
32.	*Hardwickia binata*	Thrives under the most trying maidan conditions, and is said to be a very good forage tree.
33.	Bauhinia purpurea	Leaves sparingly eaten by cattle.
34.	Albizzia odoratissima }	The young leaves are frequently nibbled by cattle.
35.	Albizzia stipulata }	
36.	*Pithecolobium saman* (The Rain Tree)	The leaves are säid to be useful for fodder.
37.	Stephegyne parviflora ..	In maidan parts the leaves are sparingly eaten by
38.	Malletus philippenasis	cattle.
39.	*Holoptelia integrifolia* ..	An excellent avenue tree. The green leaves and young shoots are greedily eaten by cattle.
40.	Salix tetrasperma	The green foliage is easily eaten by cattle, and the trees are often seen badly pollarded on this account,

In addition to the above, shrubs known locally in Kolar District as Alli (Memecylon sp.). Corvai (Ixora sp.) and Peddabalasi (Flacourtia sp.) are known to be very well eaten by cattle.

Trees which are particularly useful have been printed in italics.

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* From the "Report of the Fodder and Grazing Committee," Mysore.

APPENDIX II

SOME NEW FODDER GRASSES WORTHY OF TRIAL

I

Lespedeza.—This is a leguminous fodder plant similar to lucerne, clovers and the like, which has in recent years gained great vogue in the U. S. A. It is grown as much for the sake of fodder as for its soil improving powers both in respect of adding fertility to it and in improving its physical condition. Wheat and maize and other grain crops grown on soil on which *Lespedeza* was grown for two or three years are said to have doubled in yield on account of the improvement of the soil. It may be grown as an annual crop occupying the land for just one season, cut for hay or grazed as pasture, or can be grown as a perennial and kept on for three or four years, there being varieties which are suited for either purpose. Korean varieties are said to be larger, early maturing, coarser and large leaved.

One of the best varieties to grow is said to be *Lespedeza sericea.*

The crop can be grown even on poor soils but whether it will survive and withstand the rainless or hot season is not known. As an annual crop, sown in the beginning of the rains like any dryland grain it should be found to make good growth and probably to yield well also. The crop does not grow tall and when cut for hay is not more than 12 nches high. One ton of hay per acre is said to be an ordinary yield which with good varieties and on fertile soils may go up to 4 tons an acre. The seed rate is put down as between 15 and 40 lb. per acre according to variety. It may be left to seed, if desired, and will yield about 400 lb. of seed per acre. The fodder from such a seed crop is of course very coarse and of poor quality.

II

THE "KUDZU" VINE

The following extract from an article in *Indian Dairyman*, May 1950, by K. H. Srinivasan, Director of

Kudzu Vine grown by the Mysore
Department of Agriculture

—By courtesy of the Director of the Department.

griculture in Mysore, is about the latest account of the ew fodder crop and gives as complete information as ay be expected at present.

"Kudzu" is a perennial legume cultivated in Japan. was introduced to America as early as 1876 but did ot gain in popularity for a long time. By 1940, it had een planted over an area of 2,50,000 acres and now wing to its manifold utility it is being freely cultivated all the Southern States of America.

"Kudzu" grows into a trailing vine and as it roots asily at each node, it spreads over the ground easily and uickly. Its leaves resemble those of beans and the seed ods are like 'Cow-peas' and are borne in clusters. This ine is highly valued in America as a soil renovator, as soil binder on land liable for soil erosion and also ood fodder for livestock.

There are two kinds of "Kudzu"—The real "Kudzu" -*Pueraria thumbergiana* and the tropical one—*Pueraria haseoloides*. Many attempts seem to have been made India to grow the first kind but as it does not set seeds s cultivation has been a failure. Prof. N. V. Joshi in- oduced 'Kudzu' into India as early as 1926 and grew in the old Pusa Institute and supplied cuttings to terested growers. In Mysore, the Economic Botanist the Department of Agriculture obtained plant mate- al as early as 1932 from Japan and planted in the ebbal Farm and as the growth was tardy and the vine d not set seeds further work was not taken up. nder the auspices of the Indian Council of Agricultural esearch a Scheme was launched in the early part of 44 to investigate the conditions for flowering and tting of seeds of "Kudzu" vine. This scheme was orked at the Ferguson College, Poona, under Prof. shi. The preliminary report emphasised the point at Poona was not found suitable for the experiments d recommended that wider trials might be profitably ade in different parts of the country under different il and climatic conditions. The Indian Council of Agri- ltural Research requested all Governments for a trial "Kudzu" vine on their own account.

The Department of Agriculture, Mysore, took up further trials during the year 1946. The seeds of 'Kudzu' (*Pueraria thumbergiana*) were received by the courtesy of the U. S. Department of Agriculture from Arkansas, and some seeds of 'Kudzu' (*P. phaseoloides*) were received from Puerto Rico. The two species differ widely in their growth habits.

P. thumbergiana is a slow grower and does not set seeds. The 3 or 4 seedlings that are still surviving in the compound of the Department are stragglers and the leaf growth is sparse. The vegetative growth is noticed only during cold season, *i.e.*, from October to March. So far this species has not flowered here.

The other variety, namely *P. phaseoloides* introduced at the same time seems to hold out considerable promise. The plants are established easily from seeds or cuttings and grow exceedingly well on our red soil, and stands drought very well. The vines grow quickly and form a dense growth in a short time after the first rains; and also flower and set seeds abundantly. The Economic Botanist is of opinion that this vine answers all the claims made for 'Kudzu' in U.S.A.

In this connection it is interesting to note that we have in Mysore an allied variety, namely *Calapagonium muconoides* which is found to grow well in the Malnad parts. The growth habits of this vine are almost identical with the Tropical 'Kudzu'. It is worth-while to try this vine also.

III

"GIANT STAR GRASS"

This new grass *Cynodon plectostachyum*, Pilge, called "giant star grass" is a closely related species to the well-known Indian fodder grass *Cynodon dactylon*, the common hariali or dub grass. The grass is remarkable for its spreading habit and the length of trailing stems it develops. A single runner was found in the trials in Coimbatore to have attained a length of 21·4 ft. and with 37 nodes o ced roots, and 28 axillary shoots, 8 ft. It has been

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Feeds and fodder..

found a very vigorous grower, to do well both under irrigation and as a dry crop grown in the monsoon season. It can be started by the planting of stem cuttings or 'setts' and in the monsoon planting is established within a week. Seeds can also be sown. These germinate in 8 or 10 days and grow about 6" tall in two months. The first cut can be taken in four months after planting and subsequent cuttings at intervals of two or two and a half months. When both the S.W. and the N.E. monsoons are favourable three or four cuts can be taken in the year. Trial plantings yielded at the rate of 8,500 to 15,000 lb. per acre per cut. In Hebbal (Mysore) the grass attained a height of 2 ft. in five months.

The grass is relished and eaten readily by cattle and chemical analysis too makes it out as one of high value as a fodder. It can be cut and fed or pastured.

The grass is however cyano-genetic and contains prussic acid in all stages of its growth. Although this will rule it out as a fodder grass, it has been found that the prussic acid content was always low and very much less than the concentration generally accepted for lethal doses. Nevertheless this is an undesirable feature and cannot be ignored except after more extensive experiments.

The grass has such an extensive root system that it forms an excellent soil binder, which gives it a high erosion control value.—Facts taken mainly from an article by H. Shiva Rao and S. N. Chandrasekhar, *Monthly Bulletin of the Bangalore Dairy Cattle Society*, August 1947. Also same *Bulletin*, Vol. III, No. 3.